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PLANE STRAIN FRACTURE TOUGHNESS (KIC) DATA HANDBOOK
FOR METALS

ARMY MATERIALS AND MECHANICS RESEARCH CENTER

DECEMBER 1973

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ABSTRACT

A compilation of plane strain K_{IC} data is presented for metals manufactured in the USA and Europe, including 50 steels, 21 titanium alloys, 38 aluminum alloys, and one beryllium material. The data corresponds to static loading in neutral laboratory environment. The effect of temperature is included in the tables along with the direction of testing, the form and size of the material, its composition and heat treatment, and the specimen type and size. (Author)

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IV.

INTRODUCTION

The plane strain fracture toughness values presented in this compilation are expressed in terms of linear elastic fracture mechanics. These K_{IC} values have been obtained by the ASTM E399-72 "Standard Method of Test for Plane Strain Fracture Toughness Testing of Metallic Materials" or a similar method. This data compilation includes materials manufactured in the USA and Europe. The following factors are involved in the selection and interpretation of the K_{IC} values.

Testing Conditions

The material values shown correspond to quasi-static loading of approximately one to three minutes duration. The environment is a neutral laboratory environment in which no aggressive chemicals or extreme of humidity are intentionally introduced.

Specimen Types

K_{IC} values shown have been obtained from ASTM recommended bend and compact tensile specimens and from a variety of other specimens: four-point bend, double cantilever beam, wedge opening loading, side edge notched, center cracked specimens and a few double edge cracked and notched round specimens. Surface cracked specimen data is not included in the appendix since, although this configuration is extremely important in applications, criteria for validity of K_{IC} measurements of surface cracked specimens have not been established.

Criteria for Validity of Typical K_{IC} Values

The ASTM E399-72 requirements are taken as the general guide for validity. However, since complete details of factors cited by ASTM are usually not available, personal judgment must be exercised. For example, although all data listed pertain to fatigue-cracked specimens, the range of imposed K_I during fatiguing is usually not reported. In addition, the crack front curvature and the orientation of the crack plane with respect to the loading axis are also unknown. Other typical unknowns are the critical crack length, the details of selection of the critical load value, the appearance of the fracture surfaces, the details of fixture design to minimize friction and the linearity of the displacement gage. Therefore, it is often necessary to assume that in general the test measurements have been carried out according to good practice. In terms of specific criteria for inclusion in this tabulation the ASTM requirement of thickness greater than $2.5 (K_{IC}/\sigma_{YS})^2$, was applied. Virtually all of the data satisfied this requirement. Although it would be desirable to require that crack length exceed $2.5 (K_{IC}/\sigma_{YS})^2$, this criterion was not rigidly imposed. The minimum reported crack length for data presented in this appendix is $1.25 (K_{IC}/\sigma_{YS})^2$.

Accuracy of K_{IC} Values

In general the K_{IC} values shown are averages of several tests. The range of typical data may be interpreted to be the average shown $\pm 10\%$. In cases where the range of toughness values was large, either the entire range is shown or the extremely high values were excluded before computing the average. It should be recognized that these accuracy limits refer only to the specific results obtained and may not be appropriate in general for material of the same nominal composition, form, and size which is processed and tested elsewhere.

Parameters Influencing K_{IC}

Where available, the influence, whether significant or negligible, of material form and thickness, composition, heat treatment, testing temperature and material anisotropy and yield strength upon K_{IC} is shown by the series of data entered in the tables. In most cases where a particular heat treatment produces both the highest yield strength and toughness, data for other heat treatments are omitted. It is important to note that for some materials, data from the combination of composition and processing which leads to the highest toughness is not included in this compilation. In those instances it is not possible to obtain valid K_{IC} measurements for the particular material thickness of interest. There are additional parameters which may also influence K_{IC} values which are not shown in these tables since they are rather infrequently reported. These include melting practice, heat treating practice such as the size of quenching bath relative to the material size, and the amount of material straining during forging.

DEFINITION OF SYMBOLS AND UNITS

Units, Symbols and Nomenclature

Data is presented in the customary units used in the United States with accompanying International System Units (SI) in parentheses. The definition of units and symbols for specimen orientation and type are given preceding the tabulations.

a) Composition and Heat Treatment Codes

Code Form: Letter, Number

Letter - Identifies Composition

Number - Identifies Heat Treatment

Detailed descriptions of composition and heat treatment are at the bottom of each table. The compositional values are measured values in terms of percentage by weight, except when designated ppm (parts per million).

When only specified composition is available, the nominal specified levels are followed by the letter "N" and the maximum levels of other elements are followed by "f".

b) Orientation of Specimens

Code: First letter: Direction of Loading

Second letter: Direction of Crack Propagation

L: Direction Parallel to Primary Grain Flow Direction of Plate, Forging or Extrusion

T: Direction Parallel to Largest Dimension in Plane Transverse to L Direction

S: Direction Parallel to Smallest Dimension in Plane Transverse to L Direction

ST4: Direction 45° Between Directions of Largest and Smallest Dimension in Plane Transverse to L Direction

R: Radial Direction

C: Circumferential Direction

If a direction is ambiguous in terms of two of the above definitions, then both directions are shown.

c) Specimen Identification

Bend: 3-point Bend Specimen

Bend (4 pt): 4-point Bend Specimen

CT: ASTM Compact Tensile Specimen

WLT: Similar to CT, but with different dimensions

CC: Remotely Loaded Flat Tensile Specimen with Center Notch

DEC: Remotely Loaded Flat Tensile Specimen with Double Edge Cracks

SEN: Remotely Loaded Flat Tensile Specimen with a Single Edge Crack

NR: Round Tensile Specimen, Circumferentially Notched

DCB: Double Cantilever Beam Specimen

d) Units

Temperature: F - Degrees Fahrenheit

K - Degrees Kelvin

Stress: KSI - Kips per Square Inch

MN/m² - Mega Newtons per Square Meter

Stress Intensity: KSI $\sqrt{\text{in}}$ - Kips per Square Inch Times Square Root Inches

MN m^{-3/2} - Mega Newtons times (Meters)^{-3/2}

Length: in, mm - Inches, Millimeters

ft, m - Feet, Meters

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Steel, Saw Alloy: AISI 4330M, EN30B

Table 1

Form	Composition, Heat-Treatment	Test Orientation			Temp. (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/ln (MN/m ²)	2.5 (K _{IC}) ² in (mm)	Specimen			Ref.
		Test Orientation	Temp. °F	Temp. °K					Type	Thickness in (mm)	Width in (mm)	
AISI 4330M Cylindrical Forging 15.5 in. (394 mm) OD 6.5 in. (16.5 mm) ID 35 ft (10.7 m) Long	A,1 C-R	70(294)	181(1248)	120(131)	1.10(27.9)	NOL 1.0	(25.4)	2.75(69.8)	---	1	---	1
A,1 C-R	-20(244)	---	120(131)	---	NOL 1.0	(25.4)	2.75(69.8)	---	---	---	---	1
A,2 C-R	70(294)	157(117)	120(131)	1.47(37.3)	NOL 1.0	(25.4)	2.75(69.8)	---	---	---	---	1
A,2 C-R	-60(222)	---	45(49)	---	NOL 1.0	(25.4)	2.75(69.8)	---	---	---	---	1
Plate: 1 in. (25.4 mm) Thick	B,3 L-T	70(294)	210(1448)	55(60)	0.17(4.3)	HR D	0.353(19.9)	---	---	2	---	2
I-T	-100(200)	---	40(44)	---	NR D	0.353(19.9)	---	---	---	---	---	2
Forging: 3 in. (76.2 mm) Thick	C,4 L-T	70(294)	198(1365)	84(92)	0.45(11.4)	Bend 0.48 (12.2) 1.5	(38.1) 0.3	(7.6)	4 pt	3	4 pt	3
I-T	-65(219)	---	64(73)	---	Bend 0.48 (12.2) 1.5	(38.1) 0.3	(7.6)	4 pt	3	4 pt	3	
EN30B Bar: 0.56 in. (14.2 mm) Square	D,5 L-ST	70(294)	198(1365)	68(75)	0.29(7.5)	Bend 0.313(7.8) 0.5	(12.7) 0.25	(6.4)	5	5	5	5
D,6 L-ST	70(294)	205(1427)	65(72)	0.247(7.3)	Bend 0.315(8.0) 0.5	(12.7) 0.26	(6.6)	5	5	5	5	
D,7 L-ST	70(294)	216(1489)	56(62)	0.168(1.3)	Bend 0.315(8.0) 0.5	(12.7) 0.21	(5.3)	5	5	5	5	
D,8 L-ST	70(294)	232(1600)	74(81)	0.254(6.5)	Bend 0.315(8.0) 0.5	(12.7) 0.25	(6.4)	5	5	5	5	
D,9 L-ST	70(294)	243(1710)	68(75)	0.188(4.6)	Bend 0.315(8.0) 0.5	(12.7) 0.22	(5.6)	5	5	5	5	
COMPOSITION												
HEAT TREATMENT												
1. 1550F (1117K) Oil Quench; Temper 1050F (839K), 4 HR												
2. 1550F (1117K), Salt Quench to 600F (589K); Temper 1050F (839K), 4 HR												
3. 1700F (1209K), 1 HR, Oil Quench; Temper 600F (589K), 1 HR, Air Cool												
4. 2275F (1130K), 1 HR, Oil Quench; Temper 500F (553K), 3 HR, Air Cool												
5. Hot Rolled, Air Cooled; 1525F (1103K), 1 HR, Oil Quench; Temper 391F (473K), 1 HR												
6. Heated at 54F (30K)/sec to Ac ₃ Temp, Quench; Temper 661F (623K), 1 HR												
7. Heated at 54F (30K)/sec to Ac ₃ Temp, Quench; Temper 391F (473K), 1 HR												
8. 1796F (1253K), 1 HR, Quench in Lead Bath 931F (773K); Ausformed, 70% Reduction,												
9. 1796F (1253K), 1 HR, Quench in Lead Bath 931F (773K); Ausformed, 70% Reduction, Air Cooled; Temper 391F (473K), 1 HR.												

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Steel Low Alloy: 1. ED16, EN40C

Table 2

Test No.	Composition, Heat Treatment	Test Orientation	Temp. °F	Temp. °K	Yield Strength ksi (MN/m ²)	Typical K _{IC} ksi/in ^{3/2} (MN/m ^{3/2})	2.5 $\left(\frac{K_{IC}}{\sigma_{YS}}\right)^2$ in (mm)	Specimen		
								Type	Thickness in (mm)	Width in (mm)
SSNCDAS										
Bar: Vac. Arc. Remelt	A,1	L-R	70(294)	191(1317)	72(79)	0.355 (9.0)	(a)	---	---	---
	A,2	L-R	70(294)	202(1393)	72(79)	0.318 (8.1)	(a)	---	---	---
	A,3	L-R	70(294)	211(1455)	67(71)	0.252 (6.4)	(a)	---	---	---
C,-	T-S	T-S	70(294)	208(1354)	74(81)	0.316 (8.04)	Bend 0.5 (12.7)	1.0 (25.4)	---	60
C,-	T-S	T-S	70(294)	216(1489)	72(79)	0.278 (7.1)	Bend 0.5 (12.7)	1.0 (25.4)	---	
C,-	T-S	20(294)	222(1551)	71(78)	0.256 (6.5)	Bend 0.5 (12.7)	1.0 (25.4)	---		
EN40C:										
Bar: 0.56 in (14.2 mm) sq.	B,4	L-R	70(294)	218(1503)	60(66)	0.189 (4.8)	Bend 0.313(8)	0.5 (12.7)	0.23(5.8)	5
	B,5	L-R	70(294)	239(1648)	59(65)	0.152 (5.9)	Bend 0.313(8)	0.5 (12.7)	0.15(3.8)	
	,6	L-R	70(294)	260(1793)	55(61)	6.112 (2.8)	Bend 0.313(8)	0.5 (12.7)	0.21(5.3)	
	B,7	L-R	70(294)	317(2186)	4.4(38)	0.048 (1.2)	Bend 0.313(8)	0.5 (12.7)	0.12(5.0)	

(a) Specimen in accordance with ASTM Recommendations.

COMPOSITION

	C	Si	Mn	Ni	Cr	Nb	V	S	P	Al
A	0.35	0.27	0.33	3.99	1.69	0.44	0.05	0.009	0.026	
B	0.37	0.26	0.54	0.15	2.98	0.90	0.23	0.013	0.015	---
C	0.35N	0.4H	0.35N	4.0N	1.75N	0.45N	-	0.03N	0.03N	---

HEAT TREATMENT

1. 1705 (1203K), Air Cool; 1606F (1148K), Air Cool; -95F (203K); Temper 751F (673K), 2 hr
2. 1705 (1203K), Air Cool; 1606F (1148K), Air Cool; -95F (203K); Temper 661F (623K), 2 hr
3. 1705 (1203K), Air Cool; 1606F (1148K), Air Cool; -95F (203K); Temper 42°F (493K), 2 hr
4. 1650F (1172K), Oil Quench; Temper 571F (573K), 1 hr
5. Heated at 54F (30K)/sec to Ac₃ Temp, Immediate Quench to 70F (294K); Temper 571F (570K), 1 hr
6. 1796F (1253K), 1 hr, Quench in Lead Bath 1021F (823K); Ausformed 70% Reduction, Air Cooled;
7. 1796F (1253K), 1 hr, Quench in Lead Bath 1021F (823K); Ausformed 70% Reduction, Air Cooled;
- Temper 571F (573K), 1 hr

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STEEL, Low Alloy: H-11, H-11M

Table 3

Form	Composition, Heat-Treatment	Test Orientation	Temp °F (°C)	Yield Strength KSI (MN/m²)	Typical K_{IC} $\text{Ksi}\sqrt{\text{in}}$ ($\text{MN m}^{-\frac{3}{2}}$)	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen			Ref.	
							Type	Thickness in (mm)	Width in (mm)		
Plate: 0.0085 in (2.2 mm) Thick	A,1	L-T	75(297)	243(1675)	40(44)	0.068(1.7)	CC	0.085(2.2)	1.75(4.44)	0.7 (17.8)	54
		L-T	-100(200)	257(1760)	35(38)	0.046(1.2)	CC	0.085(2.2)	1.75(4.44)	0.7 (17.8)	
Plate: 0.5 in (12.7 mm) Thick	A,2	L-T	75(297)	231(1590)	35(38)	0.057(1.4)	CC	0.065(2.2)	1.75(4.44)	0.7 (17.8)	
		L-T	-100(200)	240(1555)	31(34)	0.042(1.1)	CC	0.085(2.2)	1.75(4.44)	0.7 (17.8)	7
Bar: 1 in (25.4 mm) Thick	B,3	L-T	200(367)	202(1393)	55(60)	0.185(4.7)	Bend	0.5 (12.7)	1.3 (25.5)	0.23(5.8)	
		L-T	75(297)	212(1462)	34(37)	0.064(1.6)	Bend	0.5 (12.7)	1.0 (25.5)	0.28(7.1)	
Bar: 1 in (25.4 mm) Thick	C,4	T-L	75(297)	204(1407)	32(35)	0.061(1.5)	Bend	0.5 (12.7)	1.0 (25.5)	0.25(6.6)	
		L-T	-50(238)	216(1459)	23(25)	0.028(0.7)	Bend	6.5 (12.7)	1.0 (25.5)	0.26(6.6)	
Forging: 3 in (76.2 mm) Thick	D,5	L-T	-100(200)	228(1572)	21(23)	0.021(0.5)	Bend	0.5 (12.7)	1.0 (25.5)	0.25(5.8)	
		L-T	200(367)	198(1365)	81(89)	0.416(10.6)	Bend	1.03 (26.2)	0.94(23.8)	0.24(6.1)	
Forging: 8 in (203 mm) Square	E,1	L-T	-50(238)	210(1448)	25(28)	0.035(0.9)	Bend	0.75 (19.1)	0.75(19.1)	0.15(3.3)	
		L-T	-100(-20)	220(1517)	23(25)	0.027(0.7)	Bend	1.0 (25.4)	1.0 (25.4)	0.26(7.0)	
Forging: 8 in (203 mm) Square	E,2	T-L	70(294)	189(1303)	45(49)	0.142(3.6)	Bend	0.48 (12.2)	1.5 (38.1)	0.3 (7.6)	3
		T-L	-65(219)	---	35(38)	---	Bend	0.48 (12.2)	1.5 (38.1)	0.3 (7.6)	
COMPOSITION	C	0.43	0.25	0.96	Mo	V	---	4 pt	4 pt	4 pt	
	Si	0.30	0.31	0.90	0.57	0.010	0.007	---	---	---	
HEAT TREATMENT	Cr	0.38	0.35	0.96	0.51	0.016	0.010	1. 1850F (1263K), 20 min; Temper 2 Hr + 2 Hr, 1050F (859K)	1. 1850F (1283K), 20 min; Temper 2 Hr + 2 Hr, 1100F (867K)	1. 1850F (1283K), 20 min; Temper 2 Hr + 2 Hr, 1100F (867K)	
	Ni	0.37	0.28	0.93	0.50	0.010	0.007	2. 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr,	2. 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr,	2. 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr,	
	Al	0.40	0.35	0.87	0.43	0.009	0.008	3. 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr,	3. 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr,	3. 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr,	
	Si	0.35	0.35	0.90	0.51	0.010	0.007	4. 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr,	4. 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr,	4. 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr,	
	Mn	0.40	0.35	0.87	0.51	0.021	0.008	5. 1550F (1117K), 1 Hr, Oil Quench; Temper 2 Hr + 2 Hr, 950F (763K), Air Cool	5. 1550F (1117K), 1 Hr, Oil Quench; Temper 2 Hr + 2 Hr, 950F (763K), Air Cool	5. 1550F (1117K), 1 Hr, Oil Quench; Temper 2 Hr + 2 Hr, 950F (763K), Air Cool	

Steel, Low Alloy: AISI 4140

Table 4

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m²)	Typical K_{IC} MN/m² (MN m⁻²)	2.5 $(\frac{K_{IC}}{\sigma_y})^2$ in (mm)	Specimen			Ref.	
							Type	Thickness in (mm)	Width in (mm)		
Bar: 1 in (25.4 mm) Thick	A,1	L-T	200(367)	173(1193)	65(72)	0.355 (9.0)	Bend	1.03 (26.2)	1.0 (25.4)	0.321 (8.2)	7
	A,1	L-T	75(297)	196(1310)	71(79)	0.359 (9.1)	4 pt	1.03 (26.2)	1.0 (25.4)	0.225 (5.7)	
	B,1	T-L	75(297)	---	70(77)	---	Bend	1.02 (25.9)	1.0 (25.4)	0.3 (7.6)	
	B,1	L-T	-50(228)	200(1379)	65(72)	0.324 (8.2)	4 pt	1.02 (25.9)	1.0 (25.4)	0.33 (8.4)	
	B,1	L-T	-100(200)	205(1413)	52(57)	0.161 (4.1)	Bend	1.02 (25.9)	1.0 (25.4)	0.24 (6.1)	
Plate: 1 in (25.4 mm) Thick	C,2	T-L	70(294)	177(1220)	90(99)	0.782 (19.9)	51N	1.0 (25.9)	4.5 (11.4)	1.6 (40.6)	21
Plate: 4 in (101.6 mm) Thick	D,3	L-T	75(297)	66(455)	55(60)	1.736 (44.1) WOL	4.0 (102)	10.22 (260)	4.0 (102)	45	
COMPOSITION											
	C	Mn	P	S	Si	Cr	Ni	Ni	Cu		
A	0.37	0.75	0.010	0.019	0.26	0.85	0.15	---	---		
B	0.36	0.81	0.008	0.025	0.27	0.91	0.17	---	---		
C	0.43	0.98	0.013	0.030	0.19	1.04	0.21	0.01	0.08		
D	0.42	0.73	0.007	0.023	0.23	0.89	0.21	0.22	<0.01	0.25	

HEAT TREATMENT

1. Austenitize 1550F (1117K) in Salt, oil Quench, Temper 800F (700K), 2 hr
2. Austenitize 1550F (1117K), 1 hr, oil Quench, Temper 900F (756K), 2 hr + 2 hr, Air Cool
3. Austenitize 1550F (1117K), 6 hr, oil Quench; Temper: 1200F (923K), 6 hr, Furnace Cool

STEEL, Low Alloy: AISI 4140 (Sheet 1 of 2)

Table 5

Form	Composition, Heat-Treat-ment	Test Orientation	Temp, °F (°K)	Yield Strength, KSI (MN/m ²)	Typical K _{IC} , ksi/in (MN/m ^{3/2})	2.5 $\left(\frac{K_{IC}}{\sigma_y}\right)^2$ ir. (mm)	Specimen			Crack Length in (mm)	Ref.
							Type in (mm)	Thickness in (mm)	Width in (mm)		
Plate: 0.125 in (3.2 mm) Thick	A,1	L-T	200(367)	220(1517)	4.0(14)	0.083 (2.1)	TC	0.10 (2.5)	3.0 (75.2)	1.2 (30.5)	8
Plate: 0.375 in (9.5 mm) Thick	A,2	L-T	-100(200)	220(1517)	4.0(14)	0.083 (2.1)	CC	0.10 (2.5)	3.0 (76.2)	1.2 (30.5)	
Plate: 0.500 in (12.6 mm) Thick	B,3	L-T	200(367)	208(1435)	6.0(69)	0.208 (5.3)	Bend	0.390(9.9)	1.0 (25.4)	0.4 (10.1)	7
Plate: 0.625 in (15.9 mm) Thick	C,4	L-T	75(297)	226(1517)	5.2(57)	0.140 (3.6)	Bend	0.390(9.9)	1.0 (25.4)	0.4 (10.1)	
Plate: 1 in (25.4 mm) Thick	D,5	T-L	75(297)	223(1538)	5.3(58)	0.141 (3.6)	Bend	0.377(9.6)	0.9 (22.9)	0.37 (9.4)	
Plate: 1.125 in (29.0 mm) Thick	E,6	L-T	-50(228)	235(1620)	4.0(14)	0.072 (1.8)	Bend	0.390(9.9)	1.0 (25.4)	0.4 (10.1)	
Plate: 1.5 in (38.1 mm) Thick	F,7	L-T	-100(200)	240(1655)	3.2(35)	0.044 (1.1)	Bend	0.390(9.9)	1.0 (25.4)	0.4 (10.1)	
Forged Bar: 5 in (127 mm) Thick	G,8	L-T	75(297)	231(1593)	6.8(75)	0.217 (5.5)	Bend	0.500(12.7)	1.0 (25.4)	---	80
Billet: 4x4.5 in (102x114 mm) Vac. Arc Remelted	H,9	L-T	70(294)	204(1504)	7.8(86)	0.371 (9.4)	SEN	0.523(13.5)	2.0 (50.8)	0.67 (17.6)	12
Forged Bar: 5 in (127 mm) Thick	I,11	T-S	70(294)	206(1400)	5.0(55)	0.148 (3.8)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	6
Forged Bar: 5 in (127 mm) Thick	I,12	T-S	70(294)	191(1317)	8.0(88)	0.128 (3.5)	Bend	1.0 (25.4)	1.0 (25.4)	0.5 (12.7)	
						0.38 (9.7)	Bend	0.95 (24.2)	1.0 (25.4)	0.2 (5.1)	7
						0.121 (3.1)	Bend	0.90 (22.9)	1.8 (45.7)	0.2 (5.1)	
						0.127 (3.2)	Bend	0.90 (22.9)	1.8 (45.7)	0.9 (22.9)	
						0.136 (3.5)	Bend	0.90 (22.9)	1.8 (45.7)	0.9 (22.9)	
						0.439 (11.1)	(a)	---	---	---	69
						0.113 (2.9)	(a)	---	---	---	

(a) Specimen in accordance with ASTM Recommendations

STEEL, Low Alloy: AISI 4340

(Sheet 2 of 2)

Table 5 (Cont.)

Form	Composition Heat Treat- ment	Test Oriente- ation	Temp °F °K	Yield Strength KSI (KN/m ²)	Typical K _{IC} KSI \sqrt{in} (MN/m ²)	Specimen		
						Type	Thickness in (mm)	Width in (mm)
COMPOSITION:								
A	0.41	0.72	0.015	0.009	0.33	1.83	0.78	0.26
B	0.43	0.84	0.006	0.005	0.27	1.78	0.78	0.26
C	0.43	0.65	0.010	0.005	0.30	1.85	0.82	0.26
D	0.42	0.71	0.010	0.012	0.25	1.77	0.80	0.23
E	0.40	0.75	0.005	0.010	0.29	1.77	0.79	0.25
F	0.41	0.69	0.018	0.012	0.29	1.87	0.78	0.22
G	0.42	0.84	0.008	0.005	0.25	1.71	0.82	0.24
H	0.38	0.74	0.001	0.005	0.28	1.86	0.84	0.26
I	0.43	0.63	0.013	0.004	0.24	1.56	1.03	0.30

HEAT TREATMENT

- Normalize 1600F (1144K), 1 Hr; Austenitize 1550K (1117K), 1 Hr, Oil Quench; Temper 1 Hr, 400F (478K)
- Normalize 1600F (1144K), 1 Hr, Austenitize 1550F (1117K), 1 Hr, Oil Quench; Temper 1 Hr, 700F (664K)
- 1550F (1117K) Salt; Oil Quench; Temper 1 Hr + 1 Hr, 500F (533K)
- 1500F (1089K), 1 Hr; Temper 1 Hr + 1 Hr, 700F (644K)
- 1500F (1089K), 0.5 Hr; Oil Quench; Temper 1 Hr, 925F (770K)
- 1500F (1089K), 0.5 Hr; Oil Quench; Temper 1 Hr, 750F (672K)
- 1550F (1117K) Salt; Oil Quench; Temper 1 Hr + 1 Hr, 800F (700K)
- 1500F (1089K), 0.5 Hr, Oil Quench; Temper 1 Hr, 600F (589K)
- 1650F (1172K), 1 Hr, Air Cool; 1550F (1089K), 1 Hr, Oil Quench; -521F (77K), 0.5 Hr Min; 400F (478K), 2 Hrs
- 1600F (1144K), 0.5 Hr, Air Cool; 1500F (1089K), 0.5 Hr, Oil Quench; -320F, 0.5 Hr, 400F (478K), 6 Hr, Air Cool
- 1543F (1113K), 0.5 Hr, Oil Quench; Temper 341F (723K), 0.75 Hr
- 1543F (1113K), 0.5 Hr, Oil Quench; Temper 571F (573K), 1 Hr

STEEL, Low Alloy: 300M (Sheet 1 of 2)

Table 6

Form	Composition, Heat-Treat- ment	Test Orientation	Temp. °F (°K)	Yield Strength ksi (MN/m ²)	Typical K_{IC} $\text{ksi}\sqrt{\text{in}}$ ($\text{MN/m}^{\frac{3}{2}}$)	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen			Ref.
							Type	Thickness in (mm)	Width in (mm)	
Forging: 6 x 10 in (152 x 254 mm) Forging: 4.5 x 4.5 in (114 x 114 mm)	A,1 B,2	L-T L-T	70(294) 70(294)	246(1703) 243(1675)	69(75) 60(65)	0.195 (5.0) 0.152 (3.9)	Bend	---	---	19
Vac. Arc Remelt										
Forging: 1 x 13 x 34 in (25.4 x 330.2 x 863. 6 mm)	C,3 C,4	L-T L-T	70(294) 70(294)	240(1655) 234(1613)	88(96) 74(81)	0.336 (8.5) 0.250 (6.4)	CC	0.372(9.4) 0.370(9.4)	5.0 (127) 5.0 (127)	1.90 1.90 2.05 (52.1)
Forging: 3 x 9 in (76.2 x 229.6 mm) Hot Rolled 2300F (1533K) Forged 2100F (1422K)	D,6	T-L T-L	70(294) -65(219)	205(1413) 233(1606)	74(81) 79(87)	0.326 (8.3) 0.287 (7.3)	CC	0.370(9.4) Bond 0.480(12.2)	5.0 (127) 1.5 (38.1)	1.75 (44.4) 0.30 (7.6) 3
Forging: 20 in (508 mm) DIA Ingot Forged at 2125F (1436K) to 3 x 3 in (76.2 x 228.6 mm)	E,6	T-L T-L	70(294) -65(219)	236(1627) ---	68(74) 45(49)	0.208 (5.3) ---	Bond 0.480(12.2) Bond 0.480(12.2)	1.5 (38.1) 1.5 (38.1)	0.30 (7.6) 0.30 (7.6)	
Billet: 3 in (76.2 mm)	F,7	L-TS	70(294)	142(976)	111(122)	1.53 (38.8)	(a)	---	---	17
	F,8	L-TS	70(294)	185(1275)	111(122)	0.9 (22.9)	(a)	---	---	
	F,9	L-TS	70(294)	206(1418)	78(86)	0.358 (9.1)	(a)	---	---	
Bil: Vacuum Arc Re- melted 1 in (25.4 mm) Dia	F,10	L-R	70(294)	238(1643)	68(75)	0.209 (5.3)	(a)	---	---	67
Forged Bar: Vac Remelt 5 in (127 mm) Dia	G,11	C-R	70(294)	255(1755)	45(50)	0.078 (2.0)	(a)	---	---	68
Billet: 4 x 4.5 in (101 x 114 mm)	H,12	L-T	72(296)	259(1785)	52(57)	0.101 (2.6)	Bond 0.9(22.9)	1.8 (45.7)	0.9 (22.9)	79
		T-L	72(296)	255(1758)	56(62)	0.121 (3.1)	Bond 0.9(22.9)	1.8 (45.7)	0.9 (22.9)	79
		T-L	72(296)	255(1758)	58(64)	1.52 (129)	Bond 0.9(22.9)	1.3 (45.7)	0.9 (22.9)	79

(a) Specimen in accordance with ASTM Recommendations

STEEL, Low Alloy: 300M (Sheet 2 of 2)

Table 6 (Cont.)

Form	Composition, Heat-Treatment		Test Orientation	Temp. °F (°K)	Yield Strength KSI (MN/m²)	Typical K _{IC} KSI/in ($\frac{MN}{m^2}$)	2.5($\frac{K_{IC}}{\sigma_y}$) ² in (mm)	Specimen		
	C	Si						Ni	Cr	V
Plate: 0.56 in (14.2 mm) Thick	J,13	L-T	70(294)	248(1710)	50(66)	0.146(3.7)	Bend 0.5 (12.7)	1.5 (38.1)	-	123
COMPOSITION	J,14	L-T	70(294)	233(1606)	60(72)	0.2(5.1)	Bend 0.5 (12.7)	1.5 (38.1)	-	
A	0.43	1.68	0.70	0.010	0.010	0.39	1.93	0.79	0.07	0.15
B	0.41	1.77	0.81	0.003	0.007	0.40	1.85	0.83	0.08	-
C	0.40	1.60	0.83	0.006	0.007	0.41	1.82	0.83	0.09	-
D	0.39	1.55	0.82	0.009	0.012	0.43	1.73	0.86	0.09	-
E	0.43	1.62	0.85	0.006	0.014	0.41	1.74	0.94	0.08	-
F	0.42	1.45	0.73	0.006	0.003	0.40	1.82	0.98	0.11	0.029
G	0.44	1.63	0.81	0.006	0.005	0.38	1.34	0.85	0.09	-
H	0.42	1.59	0.80	0.006	0.006	0.37	1.81	0.79	0.08	-
J	0.43	1.72	0.84	0.004	0.010	0.39	1.72	0.77	0.08	-

HEAT TREATMENT

1. 1600F (1144K), Quenched Warm Oil; Double Temper 2 + 2 Hr, 575F (575K)
2. 1700F (1200K), 3 1/2 hr, Air Cool; 1600F (1144K), 1 1/2 Hr; Salt Quenched to 1000F, Hold 1 Hr;
3. 1700F (1200K), 1 1/2 hr, Air Cool; 1600F (1144K), 1 1/2 hr, Air Cool; Double Tempered 575F(575K) 2 + 2 Hr Air Cool
4. 1700F (1200K), 1 1/2 hr, Air Cool; 1600F (1144K), 1 1/2 hr, Oil Quenched; Double Temper, 2 + 2 Hr, 500F (533K)
5. 1700F (1200K), 1 1/2 hr, Air Cool; 1600F (1144K), 1 1/2 hr, Oil Quenched, Double Temper, 2 + 2 Hr, 675F (630K)
6. 1600F (1144K), 1 hr, Oil Quenched; Double Temper, 3 + 3 Hr, 600F (589K), Air Cool
7. 1705F (1203K), Air Cool; 1777F (1243K), Oil Quench; 1200F (922K), 2 + 2 Hr
8. 1705F (1203K), Air Cool; 1777F (1243K), Oil Quench; 1111F (873K), 2 + 2 Hr
9. 1705F (1203K), Air Cool; 1777F (1243K), Oil Quench; 1021F (833K), 2 + 2 Hr
10. 1705F (1203K), Air Cool; 1777F (1243K), Oil Quench; 481F (523K), 2 + 2 Hr
11. 1705F (1203K), Air Cool; 1615F (1155K), Oil Quench; 571F (573K), 5 + 5 Hr
12. 1700F (589K), 2 + 2 Hr
13. 1550F (1117K), Oil Quench; 550F (561K), 2 + 2 Hr
14. 1600F (1144K), Oil Quench; 550F (561K), 2 + 2 Hr

A G -

SHEET, Low Alloy: 16AC (Sheet 1 of 2)

Table 7

Form	Composition, Heat-Treat-ment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} (MN/m ^{3/2})	2.5 $\frac{K_{IC}}{\sigma_y}$ ² in (mm)	Specimen			Crack Length in (mm)	Ref.
							Type	Thickness in (mm)	Width in (mm)		
Plate: 0.095 in (2.4 mm) Thick	A,1	T-L	75(297)	236(1628)	46(50)	0.095(2.4)	CC	0.095(2.4)	1.75 (44.4)	0.7 (17.8)	12
		L-T	-100(200)	253(1745)	37(41)	0.053(1.5)	CC	0.095(2.4)	1.75 (44.4)	0.7 (17.8)	
Plate: 0.5 in (12.7 mm) Thick	B,2	L-S	-200(144)	263(1815)	36(40)	0.047(1.2)	CC	0.095(2.4)	1.75 (44.4)	0.7 (17.8)	
		L-S	70(294)	203(1400)	110(120)	0.734(18.6)	Bend	0.75 (19.1)	1.5 (38.1)	0.368 (9.3)	20
Plate: 0.75 in (19.1 mm) Thick	B,1	---	70(294)	231(1533)	61(66)	0.174(4.4)	Bend	0.257(6.5)	0.486(12.3)	0.245(6.2)	
		---	70(294)	247(1703)	67(74)	0.735(18.7)	Bend	0.75 (19.1)	0.75 (19.1)	---	46
Plate: 0.8 in (20.3 mm) Thick	C,3	---	175(353)	211(1455)	92(101)	0.475(12.1)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	51
		---	70(294)	217(1496)	94(103)	0.469(11.9)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
Plate: 1.5-1.8 in (38.1-45.7 mm) Thick	---	---	-20(244)	226(1558)	72(79)	0.254(6.4)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
		---	175(353)	211(1455)	92(101)	0.475(12.1)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
Forging: 0.8 in (20.3 mm) Thick	---	---	70(294)	217(1496)	79(87)	0.331(8.4)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
		---	-20(244)	226(1558)	50(55)	0.122(3.1)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
Forging: 1.5-1.8 in (38.1-45.7 mm) Thick	---	---	-65(219)	228(1572)	46(51)	0.102(2.6)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
		---	70(294)	214(1476)	97(107)	0.514(13.0)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
Billet: 3 in (72.6 mm) Dia	D,4	I.R	70(294)	208(1454)	105(115)	0.637(16.2)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	67
		D,5	I.R	70(294)	215(1482)	84(92)	0.382(9.7)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)
COMPOSITION											
A	0.47	0.85	0.007	0.005	0.20	0.57	1.07	1.01	0.08	0.06	
B	0.45	0.69	0.008	0.006	0.026	0.55	1.08	1.01	0.08	0.07	
C	0.475N	0.75N	0.015N	0.015N	0.22N	0.55N	1.0N	1.0N	0.12N	---	
D	0.47	0.90	0.010	0.007	0.30	0.55	1.0	0.92	0.10	0.026	

STEEL, Low Alloy: D6AC (Sheet 2 of 2)

Table 7 (Cont.)

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical		Specimen Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Ref.
					K_{IC} $\text{MN/m}^{\frac{3}{2}}$	K_{Ic}/\sqrt{in} $(\text{MN/m}^{\frac{3}{2}})$				

HEAT TREATMENT

1. 1650F (1117K); 1550F (1117K), Oil Quenched 150F (339K); Temper 1 Hr + 1 Hr, 500F (533K)
2. 1550F (1117K) in Salt, 20 min, Oil Quench, Temper 1 Hr + 1 Hr, 500F (533K)
3. 1700F (1100K); Quench in Furnace to 975 + 25F (797 + 14K), at 6F (3.3K) per minute from 1350 to 1150F (1006 to 894K), Oil Quench 140F (334K); Temper 1000-1025F (811-823K), 1 Hr + 1 Hr
4. 1705F (1203K), Air Cool; 1615F (1153K), Oil quench at 363F (457K), 1 Hr; Temper 841F (723K), 2 Hr
5. 1705 (1203K), Air Cool; 1615 F (1153K), Oil quench at 363F (457K), 1 Hr; Temper 1021F (823K), 2 Hr

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SILVER, Low Alloy: EN24, Ni-Cr-Mo-V

Table 8

EN24 Ingot:	Form	Compo- sition, Heat Treat- ment	Test Orien- tation	Temp °F (°K)	Yield Strength ksi (MN/m ²)	Typical K _{IC} (MN/m) KSI/ln ($\frac{K_{IC}}{\sigma_y}$) in (mm)	2.5 ($\frac{K_{IC}}{\sigma_y}$) in (mm)	Specimen		
								Type	Thickness in (mm)	Width in (mm)
A,1 Bar 1.0 x .312 in (25.4 x 7.9 mm)	A,1 L-ST	70(294)	231(1590)	64(70)	0.192 (4.9)	Bend 0.492 (12.5)	0.384 (25)	-	91	
A,2	A,2	70(294)	220(1520)	37(41)	0.071 (.8)	Bend 0.482 (12.5)	0.984 (25)			
A,3	A,3	70(294)	206(1420)	75(83)	0.331 (3.4)	Bend 0.482 (12.5)	0.984 (25)			
A,4	A,4	70(294)	206(1420)	41(45)	0.099 (2.5)	Bend 0.482 (12.5)	0.984 (25)			
Ni-Cr-No-V	Ni,5	70(294)	186(1285)	71(78)	0.364 (9.3)	Bend 0.482 (12.5)	0.984 (25)			
Bar	H,6	H,6	106(294)	263(1637)	45(46)	0.074 (1.9)	Bend 0.187 (4.7)	0.75(19.1)	---	47
	H, ^a	H, ^a	106(294)	251(1753)	49(53)	0.096 (2.4)				
	H, ^b	H, ^b	106(294)	241(1683)	51(56)	0.112 (2.8)				
	H, ^c	H, ^c	106(294)	247(1725)	67(73)	0.165 (4.7)				
	C,1C	C,1C	106(294)	236(1648)	63(69)	0.180 (4.6)				

COMPOSITION

C	Mn	Si	P	S	N	Cr	Mo	Sn	Cu	Al	V
A	0.39	0.57	0.28	0.021	0.038	1.76	1.10	0.24	0.023	0.16	0.020
B	0.45	0.44	0.79	0.012	0.008	1.7	1.31	0.88	-	-	0.23
C	0.39	1.15	1.45	0.008	0.006	1.90	0.09	0.30	-	-	0.24

HLAT TREATMENT

1. 154F (1113K), Hold 40 Sec, Oil Quench, 7 cycles; 1596F (1113K), Hold 1 min, Oil Quench,
2 cycles; 661F (623K), 4 hr
2. 156F (1123K), Hold 1 min, Oil Quench; 181F (523K), 1 hr
3. 156F (1123K), Hold 1 min, Oil Quench, 4 cycles; 661F (623K), 4 hr
4. 156F (1123K), 1 hr, Oil Quench; 661F (623K), 1 hr
5. 156F (1123K), 1 hr, Oil Quench; 841F (723K), 1 hr
6. 1690F (1193K), Oil Quench; refrigerated at -95F (-203K); Tempered 461F (523K)
7. 1690F (1193K), Oil Quench; refrigerated at -95F (-203K); Tempered 571F (573K)
8. 1690F (1193K), Oil Quench; refrigerated at -95F (-203K); Tempered 661F (623K)
9. 156F (1123K), Oil Quenched; temper 706F (648K); Tempered 661F (623K)
10. 156F (1123K), Oil Quenched; Temper 481F (523K)

SHEET, NICKEL: 9Ni-4Co-2C

Table 9

Form	Composition, Heat Treatment	Compo- sition, Heat Treatment		σ_y (σ_{yP}) in k _f	Yield Strength σ_y (σ_{yP}) in k _f	Typical K_{IC} ASTM ($MN/m^{\frac{3}{2}}$)	$2\sqrt{\frac{K_{IC}}{\sigma_y}}$ in (mm)	Specimen		
		Orientation	Crack Length in mm					Type	Thickness in mm	Width in mm
Plate: 1.5 in (38.1 mm) Thick	A,1	I-I.	-100 (200)	"8 (1365)	132 (145)	1.11 (28.2)	Bend 1.4 (25.5)	2.8 (7.1)	1.4 (35.5)	4
Plate: 2.5 in (63.5 mm) Thick	A,2	I-I	-321 (78)	240 (1655)	49 (54)	0.10 (2.6)	Bend 1.1 (35.5)	2.8 (7.1)	1.4 (35.5)	
Plate: 4 in (101.6 mm) Thick	B,2	S-I.	73 (246)	16.0 (1310)	142 (156)	1.53 (38.9)	CI 2.0 (50.8)	6.0 (152)	2.9 (73.7)	110
COMPOSITION:										
A	0.21	3.1	0.0	Mn	Mo	Cr	C	P	S	Cu
B	0.19	9.40	4.24	3.0	0.92	0.74	0.07	0.000	0.007	0.01
				0.29	0.90	0.85	0.17	0.005	0.005	0.17

HEAT TREATMENT

1. Normalize 1650F (1172K), 1.5 hr, Air cool, austenitize 1500F (1089K), 1.5 hr water quench;
 2. temper 1025F (825K), 6 hr,
- 1525F (1102K), 0.1 quench; -100F (-200K), .1 hr; 1025F (825K), 6 hr

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STEEL, Nickel: 9Ni-4Co-.3C

Table 10

Form	Composition, heat treatment	Test Orientation	Temp. σ_F ($^{\circ}$ F.)	Yield Strength KSI (MN/m^2)	Typical		Type	Thickness in (mm)	Width in (cm)	Crack Length in (mm)	Specimen Ref.
					K_{IC}	$2.5 \left(\frac{K_{IC}}{\sigma_F} \right)^2$					
Plate: 3 in (76.2 mm) Thick	A,1	T-L	82 (300)	215 (1432)	88 (5.5)	0.44 (11.2)	CT	1.0 (25.4)	3.0 (76.2)	1.5 (38.1)	110
Forging: 4.5 x 4.5 in (114.3 x 114.3 mm)	B,2	L-T	70(294)	223(1535)	99(110)	0.49 (12.5)	DEC C SO(12.7)	3.0 (76.1)	0.5(12.7)	0.5(12.7)	16
Forging: 3 in (76.2 mm) Thick	C,3	T-L	-100(200)	202(1392)	64 (69)	0.25 (6.4)	DEC O 5.0(12.7)	3.0 (76.1)	0.5(12.7)	0.5(12.7)	
			150(339)	175(1344)	108(124)	0.95 (73.2)	WOL 2.0 (50.8)	5.1 (13.0)	1.8 (45.7)	1.8 (45.7)	11
			177(1220)	177(1220)	107(126)	1.61 (41.0)	WOL 3.0 (50.8)	2.25 (57.3)	1.0 (25.4)		
			70(294)	70(294)	100(110)	0.798(20.3)	WOL 2.0 (50.8)	5.1 (13.0)	1.8 (45.7)	1.8 (45.7)	
			0(355)	187(1289)	105(114)	0.788(20.0)	WOL 2.0 (50.8)	5.1 (13.0)	1.8 (45.7)	1.8 (45.7)	
			-40(233)	188(1290)	111(121)	0.871(22.1)	WUL 2.0 (50.8)	5.1 (13.0)	1.8 (45.7)	1.8 (45.7)	
			-75(214)	188(1296)	112(122)	0.868(22.6)	WOL 2.0 (50.8)	5.1 (13.0)	1.8 (45.7)	1.8 (45.7)	

COMPOSITION

	<u>Si</u>	<u>Ni</u>	<u>Co</u>	<u>Mn</u>	<u>Cr</u>	<u>Y</u>	<u>P</u>	<u>S</u>	<u>Sl</u>
A	0.21	8.90	4.24	0.20	0.92	0.74	0.07	0.009	0.007
B	0.32	7.62	4.25	0.16	0.94	1.05	0.08	0.005	0.007
C	0.26	8.41	3.9	0.33	0.48	0.40	0.07	0.008	0.01

HEAT TREATMENT

1. 1525 (1103K), 0.1 hr Quench; -100F (200K), 3 hr; 1000F (811K), 5 hr
2. 1125F (680°) 16 Hr, Air Cool; 1700F (1209K) 1 Hr, Air Cool; 1550F (1115K), 0.5 Hr, Split Quench to 460F (812K); Hold 7 Hr;
3. Temper 1000F (811K) 2 Hr, Air Cool
3. 1550F (1115K), 2 Hr; Double Tempr, 2 Hr + 2 Hr, 1000F (811K)

STEEL, NiCrCo-4SC

Table 1:

Form	Composition, Heat Treatment	Test Orientation	Temp (°K)	Yield Strength ksi (MN/m^2)	Typical K_{IC} $\text{ ksi}\sqrt{\text{in}}$ ($\text{MN m}^{-\frac{3}{2}}$)	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen		
							Type	Thickness in (mm)	Width in (mm)
Plate: 0.95 in (2.4 mm) Thick	A,1	L-T	75(297)	220(1510)	50(55)	0.125(3.2)	FC	0.095(2.4)	1.75(44.4)
		T-L	75(297)	224(1515)	50(55)	0.124(3.2)	CC	0.095(2.4)	1.75(44.4)
		L-T	-100(200)	225(1510)	51(56)	0.131(3.3)	CC	0.095(2.4)	1.75(44.4)
		L-T	-200(144)	226(1575)	47(52)	0.106(2.7)	CL	0.095(2.4)	1.75(44.4)
Plate: 1 in (25.4 mm) Thick	B,2	T-L	75(297)	235(1610)	86(95)	0.34(8.6)	Bend	0.875(22.2)	0.875(22.2)
Forging: 9 x 9 x 24 in (228.6 x 228.6 x 609.6 mm)	C,3	L-T	70(294)	198(1365)	109(120)	0.755(19.2)	CC	1.0(25.4)	9.0(228.6)
		L-T	-110(194)	211(1453)	55(60)	0.172(4.3)	CC	1.0(25.4)	9.0(228.6)
Forging: 3 x 9 x 24 in (76.2 x 228.6 x 609.6 mm)	D,4	T-L	70(294)	225(1550)	90(98)	0.4(10.2)	Bend	0.480(12.2)	1.5(38.1)
		T-L	-65(219)	---	68(75)	---	Bend	0.480(12.2)	1.5(38.1)
Forging: 3 x 9 x 24 in (76.2 x 228.6 x 609.6 mm)	E,5	T-L	300(422)	195(1344)	83(90)	0.453(11.5)	Bend	0.480(12.2)	1.5(38.1)
		T-L	75(297)	225(1550)	89(97)	0.392(10.0)	Bend	0.480(12.2)	1.5(38.1)
		L-T	-65(219)	246(1655)	89(97)	0.344(8.7)	Bend	0.480(12.2)	1.5(38.1)
		T-L	-65(219)	---	68(75)	---	Bend	0.480(12.2)	1.5(38.1)
		S-L.	-64(219)	---	79(87)	---	Bend	0.480(12.2)	1.5(38.1)
		T-L	-110(194)	245(1675)	62(68)	0.163(4.1)	Bend	0.480(12.2)	1.5(38.1)
						4 pt			

COMPOSITION

C	Ni	Co	Mn	Cr	V	P	S	Si	
A 0.45	8.76	3.76	0.12	0.30	0.06	0.005	0.009	0.01	1. 145F (1060K), 0.1 Quench; Temper 1 hr + 1 hr, 600°F (599K)
B 0.43	8.00	4.0	0.02	0.08	0.09	0.12	---	0.01	2. 160F (1144K), Air Cool; 1450F (1061K) 0.5 hr, Salt Bath
C 0.43	8.09	3.81	0.13	0.13	0.09	0.005	0.009	0.01	3. 160F (1144K), 1 Hr, Air Cool; 1450F (1061K), 30 min; Salt Quench, 450F (505K), 6 Hr, Air Cool;
D 0.45	7.90	4.26	0.09	0.22	0.33	0.10	0.003	0.01	Double Temper 1 Hr + 1 Hr, 700F (644K)
E 0.44	7.79	4.03	0.19	0.29	0.32	0.08	0.010	0.009	4. 150F (1089K), 1 Hr, Salt Quench 475F (519K) 6 Hr
									5. 1550 - 1650F (1117-1172K) 1 Hr, Air Cool; 1150F (894K), 30 min; 1500F (1089K) 1 Hr; 465F (514K) Salt Bath,
									6 Hr, Air Cool

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HEAT TREATMENT

STEEL: 10 Nickel

Table 12

Form	Composition, Heat-Treat- ment	Test Orient- ation	Temp. °F (°K)	Yield Strength KSI (Mev/in ²)	Typical K_{IC} $\text{ksi}/\sqrt{\text{in}}$ ($\text{MN/m}^{3/2}$)	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen			Ref.	
							Type	Thickness in (mm)	Width in (mm)		
Plate: 0.5 in (12.7 mm) Thick	A,1	L-T	70(294)	257(1772)	51(56)	0.98 (2.5)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	80
		T-L	70(294)	256(1765)	52(57)	0.103 (2.6)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	
	B,2	T-L	70(294)	256(1765)	87(96)	0.352 (8.9)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	
	C,2	T-L	70(294)	272(1875)	73(80)	0.216 (5.5)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	
	D,5	T-L	70(294)	257(1772)	77(85)	0.618 (15.7)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	

COMPOSITION

	C	Mn	P	S	Si	Al	Cr	Ni	Mo	Al	N	O	C ₂₃
A	0.26	0.15	0.001	0.003	0.12	10.08	2.00	0.98	0.008	0.002	0.01	15.2	
B	0.23	0.13	0.001	<0.002	0.13	9.68	1.94	0.98	0.002	0.003	0.01	12.3	
C	0.25	0.14	0.002	0.003	0.11	10.10	1.99	1.01	0.004	0.062	0.003	14.6	
D	0.25	0.11	0.001	0.003	0.12	10.0	1.57	0.79	0.004	0.001	0.002	12.6	

HEAT TREATMENT

1. 1650F (1172K), 1 hr, Water Quenched; 1500F (1089K), 1 hr., Water Quench; Temper 950F (783K), 1 hr, Water Quench.
2. Heat to 1350F (839K), Hold, Heat to 1550F (1117K), Hold, Water Quench, Repeat Cycle 4 Times, Temper 950F (783K), 5 hr
3. Heat to 1120F (879K), Hold 6 Sec, Heat to 1450F (1060K), Hold 8 Sec, Water Quench, Repeat Cycle 4 Times, Temper 400F (478K), 5 hr

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STEEL: Maraging 12 Nickel

Table 13

Form	Composition, Heat Treatment	Test Orientation	Temp °F •K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN/m ³)	2.5 $\left(\frac{K_{IC}}{\sigma_y}\right)^2$		Specimen		Crack Length in (mm) Ref.
						Type in (mm)	Thickness in (mm)	Type in (mm)	Width in (mm)	
Plate: 1 in (25.4 mm) Thick	A,1	L-T	70(294)	171(1179)	100(110)	0.86 (21.8)	SEN	1 (25.4)	4.5 (114.3)	1.6 (40.7) 21
Plate: 2 in (50.8 mm) Thick	B,1	T-L	70(294)	185(1276)	120(132)	1.175 (29.9)	SEN	1 (25.4)	4.5 (114.3)	1.6 (40.7)
	C,1	L-T	20(294)	175(1207)	125(138)	1.28 (32.5)	Bend	2 (50.8)	5.95(151)	1.6 (40.7) 85
	D,2	-	70(294)	186(1282)	147(162)	1.56 (39.6)	Bend	2 (50.8)	2 (50.8)	- 85

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	Tl	Al
A	0.033	0.08	0.007	0.005	0.07	12.5	4.81	3.55	0.21	0.16
B	0.033	0.08	0.007	0.005	0.07	12.5	4.71	3.65	0.21	0.16
C	0.23	0.088	0.004	0.008	0.094	12.1	5.21	2.85	0.24	-
D	0.24	0.044	0.007	0.013	0.042	11.72	5.38	3.18	0.30	0.47

HEAT TREATMENT

1. 1500F (1089K); Temper 900F (756K), 3 hr
2. 1500F (1089K); Temper 900F (756K), 30 hr

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STEEL: 10Ni: Maraging: 200 Grade

Table 14

Form	Composition, Heat Treatment	Test Orientation	Temp. °F (°K)	Yield Strength ksi (MN/m ²)	Typical K _{IC} ksi $\sqrt{\text{in}}$ (MN m $^{-\frac{3}{2}}$)	$2.5 \frac{(K_{IC})^2}{(\sigma_{ys})}$ in (mm)	Specimen		
							T ₁	A ₁	M ₀
Plate: 1 in (25.4 mm) Thick	A, I	L-T	-321(18)	241(1662)	115(127)	0.569 (14.5)	Bend	1.0 (25.4)	5.0 (76.2)
Plate: 2 in (50.8 mm) Thick	-2	L-T	75(297)	187(1289)	152(167)	1.65 (42.0)	Bend	2.0 (50.8)	4.0 (111.6)
Plate: 2 in (50.8 mm) Thick	D, 3	L-S	70(294)	197(1356)	104(114)	0.697 (17.7)	(a)	---	---
		L-T	70(294)	192(1324)	100(110)	0.687 (17.2)	(b)	---	---
		T-S	70(294)	194(1334)	78(86)	0.404 (10.3)	(a)	---	---
		T-L	70(294)	195(1347)	75(83)	0.370 (9.4)	(a)	---	---
		S-L	70(294)	198(1365)	70(75)	0.312 (7.9)	(a)	---	---
Plate: 2.13 in (54mm) Thick	B, 4	T-L	75(297)	206(1420)	170(187)	1.7 (43.2)	Bend	2.0 (50.8)	4.0 (101.6)
		T-L	-100(200)	229(1580)	164(179)	1.28 (32.5)	Bend	2.0 (50.8)	4.0 (101.6)
Plate: 4.25 in (108 mm) Thick Con.E1, Vac Remelt, Hot Rolled at 2300°F (1553K) at 2300°F (1553K)	C, 5	L-T	75(297)	234(1613)	92(101)	0.386 (9.8)	Bend	3.94 (100)	7.89 (200)
	C, 6	L-T	75(297)	211(1455)	103(113)	0.596 (15.1)	CT	3.94 (100)	6.31 (160)
	C, 7	L-T	75(297)	190(1310)	129(142)	1.152 (2.93)	Bend	3.94 (100)	7.87 (200)
	C, 8	L-T	75(297)	174(1200)	180(198)	2.675 (68.0)	Bend	3.93 (100)	7.86 (200)
	C, 9	L-T	75(297)	166(1145)	187(206)	3.173 (80.6)	CT	3.93 (100)	6.31 (160)

(a) Specimen in accordance with ASTM Recommendations

COMPOSITION

C	Mn	F	S	Si	Ni	Co	No	T ₁	A ₁	Cr	2.5
A	0.003	0.02	0.003	0.007	0.005	17.90	7.75	2.96	0.20	-	5.
B	0.005	0.03	0.005	0.008	0.002	18.40	8.50	3.34	0.20	0.07	6.
C	0.02	0.07	0.001	0.009	0.08	17.78	7.07	4.46	0.185	-	7.
D	0.035	0.121	0.010	0.011	0.121	18N	7.5N	3.25N	0.28N	0.1N	8.
							0.5N	9.	1650F (1172K), 4.5 Hr, Air Cool; 1100F (867K), 24 Hr	25 <	100F (867K), 24 Hr

HEAT TREATMENT

1. 1500F (1059K), 93 Min, Water Cooled; 1160F (899K), 93 Min, Water Quench
2. 1500F (1059K), Aged 300F (756K), 3 Hr
3. Aged 895F (753K), 3 Hr
4. 1650F (1172K), 2 Hr, Air Cool; 1450F (1060K), 2 Hr, Air Cool;
5. Aged 900F (756K), 2 Hr, Air Cool; 850F (728K), 100 Hr
6. 1650F (1172K), 4.5 Hr, Air Cool; 1000F (811K), 6 Hr
7. 1650F (1172K), 4.5 Hr, Air Cool; 1050F (839K), 6 Hr
8. 1650F (1172K), 4.5 Hr, Air Cool; 1100F (867K), 6 Hr

STEEL, 18 Ni Maraging: (250 Grade), DTD 5212, G100, G110, Marval 18 (Sheet 1 of 3) Table 15

Form	Compo- sition, Heat Treat- ment Oriente- ment	Test Temp. °F (°K)	Yield Strength KSI (MN/m ²)	Typical K_{IC} / $K_{Ic}\sqrt{in}$ (MN m ^{-1/2})	$2.5 \left(\frac{K_{IC}}{\sigma_y s} \right)^2$ in (mm)	Specimen			Crack Length in (mm)	Ref.
						Type	Thickness in (mm)	Width in (mm)		
250 Grade										
Plate: 1 in (25.4 mm) Thick	A,3	L-T	79(294)	259(1786)	68(74)	0.172(4.3)	Bend	0.250(6.4)	2.0 (5C.8)	---
Rolled to 2 in (50.8 mm) thickness from Press Forged Slab	B,2	L-T	70(294)	227(1565)	96(105)	0.447(11.3)	Bend	1.8 (45.7)	3.75(95.3)	---
	B,2	L-T		232(1600)	85(93)	0.336(8.5)	Bend	1.8 (45.7)	3.75(95.3)	---
	B,3	L-T		259(1786)	64(92)	0.263(6.7)	Bend	1.8 (45.7)	3.75(95.3)	--
	B,4	L-T		259(1786)	80(87)	0.239(6.1)	Bend	1.8 (45.7)	3.75(95.3)	---
Forging: 3 in (76.2 mm) Thick	C,5	T-L	70(294)	243(1675)	99(108)	0.415(10.5)	Bend	0.480(12.2)	1.5 (38.1)	0.3 (7.6) 3
		T-L	-65(219)	---	90(98)	---	4 pt	0.480(12.2)	1.5 (38.1)	0.3 (7.6)
Plate: 1 in (25.4 mm) Thick	D,6	-	70(294)	246(1696)	105(114)	0.455(11.6)	Bend	1.00 (25.4)	3.0 (76.2)	---
	-	3(255)	250(1724)	72(78)	0.207(5.3)	Bend	1.00 (25.4)	3.0 (76.2)	---	
	-	-100(200)	300(2068)	75(82)	0.156(4.0)	Bend	1.00 (25.4)	3.0 (76.2)	---	
	-	-200(144)	260(1834)	52(57)	0.100(2.5)	Bend	1.00 (25.4)	3.0 (76.2)	---	
	-	-385(75)	230(1586)	40(44)	0.075(1.9)	Bend	1.00 (25.4)	3.0 (76.2)	---	
Forging: 4.5 x 4.5 in (114.3 x 114.3 mm) Vacuum Arc Remelt	E,7	L-T	-110(194)	273(1882)	86(94)	0.248(6.3)	SEN	0.250(6.4)	1.0 (25.4)	0.500(12.7) 16
Forging: 13 x 13 in (330.2 x 330.2 mm) Vacuum Arc Remelted	F,7	T-L	-110(194)	272(1875)	80(87)	0.216(5.6)	SLN	0.250(6.4)	1.0 (25.4)	0.500(12.7)
		S-T	-110(194)	259(1786)	82(89)	0.251(6.4)	SEN	0.250(6.4)	1.0(25.4)	1.500(12.7) 16
	ST4-ST4	-110(194)		262(1806)	82(89)	0.245(6.2)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)
				26.1(1806)	72(78)	0.189(4.8)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)

STHEL: 18 Ni Maraging (250 Grade), DTD 5212, G100, G110, Marval 18 (Sheet 2 of 3) Table 15 (Cont.)

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (KN/m ²)	Typical K _{IC} KSI/ $\sqrt{\text{in}}$ ($\text{MN m}^{-\frac{3}{2}}$)	2.5 $\left(\frac{K_{IC}}{\sigma_y s}\right)^2$ in (mm)	Specimen			Crack Length in (mm)	Ref.
							Type	Thickness in (mm)	Width in (mm)		
Plate: 1.5 x 23 in (38.1 x 350.2 mm)	I.S.	-110(194)	262(1806)	83(90)	0.251(6.4)	S.E.N.	0.250(6.4)	1.0(25.4)	0.500(12.7)	16	
	T.L.	-110(194)	267(1841)	73(80)	0.187(4.7)	S.E.N.	0.250(6.4)	1.0(25.4)	0.500(12.7)		
	ST	-110(194)	267(1841)	69(75)	0.167(4.2)	C.T.	0.500(12.7)	1.0(25.4)	0.500(12.7)		
	T.L.	-110(194)	264(1820)	84(92)	0.253(6.4)	S.E.N.	0.250(6.4)	1.0(25.4)	0.500(12.7)		
<hr/>											
<u>DTD 5212</u>											
Forged Plate: 2.5 in (63.5 mm) Thick											
<u>G100</u>											
Forged Bar: 5 in (127 mm) Thick		H, 11	T-S	70(294)	204(1407)	88(97)	0.465(11.8)	(a)	---	---	
		H, 12	T-S	20(294)	225(1551)	82(90)	0.332(8.4)	(a)	---	---	
		H, 13	T-S	70(294)	248(1796)	83(92)	0.280(7.1)	(a)	---	---	
<u>G110</u>											
Bar: 4.9 in (125 mm) Thick, Vac. Melted		G, 9	L-ST	70(294)	*262(*1806)	92(101)	---	(a)	---	---	
		ST-I.	70(294)	*260(*1793)	85(93)	---	(a)	---	---	---	
Bar: 8 in (203) Sq Double Vac. Melted		G, 9	ST-L	70(294)	*265(*1834)	82(90)	---	(a)	---	---	
Plate:		G,-	---	70(294)	235(1626)	80(88)	0.290(7.4)	Bend	0.715(18.2)	1.0(25.4)	0.47(11.9)
Marval 18		-,-	T-S	70(294)	245(1689)	100(110)	0.416(10.6)	Bend	0.5(12.7)	1.0 (25.4)	60
(a) Specimen In accordance with ASTM Recommendations											
* Tensile Ultimate Values											

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(a) Specimen In accordance with ASTM Recommendations

* Tensile Ultimate Values

STEEL: 18 Ni Maraging (250 Grade), DTD 5212, G100, G110, Marval 18 (Sheet 3 of 3) Table 15 (Cont.)

COMPOSITION Form	Composition, Heat-Treatment				Temp. °F ("K)	Yield Strength KSI (MN/m ²)	Typical K_{IC} KSI $\sqrt{\text{in}}$ ($MN = \frac{3}{2}$)	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen		
	Test Orientation	•F	Thickness in (mm)	Width in (mm)					Crack Length in (mm)	Ref.	
A	.020 0.05	.09	0.006	0.005	18.35	5.32	7.18	0.04	0.32	-	
B	.006 0.06	.01	0.006	0.007	18.47	4.81	7.40	0.11	0.40	0.002 C.01 0.05	
C	.030 0.10	.10	0.005	0.008	18.05	5.08	7.66	0.15	0.40	-	
D	.003 0.002	.003	0.002	0.004	17.1	4.65	7.60	-	0.50	-	
E	.020 0.05	.03	0.003	0.003	18.20	4.71	7.38	0.14	0.42	0.003 0.016 0.05	
F	0.015±0.2M	0.01M	0.01M	0.01M	18.0N	4.9N	7.75N	0.10N	0.45N	-	
G	0.01M 0.05M	0.05M	0.005M	0.005M	17.5N	4.85N	8.0N	-	0.5N	-	
H	.003 0.05	.05	0.005	0.004	18.3	4.72	7.64	0.119	0.8	-	

HEAT TREATMENT

1. Mill Anneal; 900F (756K) 3 hr
2. 1500F (1089K), Air Cool; Aged 800F (700K) 6 hrs
3. 1500F (1089K), Air Cool; Aged 1000F (811K) 6 hrs
4. 1500F (1089K), Air Cool; Aged 900F (756K) 6 hrs
5. 1500F (1089K), Air Cool; Aged 900F (756K) 24 hrs
6. 1650F (1172K), 1 hr, Water Quench; 1525F (1103K) 1 hr, Water Quench; Aged 900F (750K) 5 hr, Water Quench
7. 1500F (1089K), Air Cool; Aged 950F (783K) 3 hr, Air Cool
8. 1489-1525F (1083-1103K), Air Cool; 900F (758K), 3 hr, Air Cool
9. 1507F (1093K), Air Cool; 895F (755K), 3 hr, Air Cool
10. 1507F (1093K), Aged 913F (763K)
11. 1471-1650F (1073-1173K), Air Cool; 796F (698K), 1.5 hr
12. 1471-1650F (1073-1173K), Air Cool; 895F (753K), 1.5 hr
13. 1471-1650F (1073-1173K), Air Cool; 895F (753K), 2.5 hr

STEEL, 18 Ni Maraging. 300 Grade and G125

Table 16

Form	Composition, Heat-Treat- ment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K_{IC} $KSI\sqrt{in} \left(MN\ m^{-\frac{3}{2}} \right)$	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen:		
							Type	Thickness in (mm)	Width in (mm)
300 Grade									
Plate: 0.5 in (2.7 mm) Thick	A,1	T-L	600(589)	236(1627)	80(87)	0.287 (7.3)	CC	0.25 (6.4)	3.0
		T-L	70(294)	280(1931)	68(74)	0.147 (3.7)	CC	0.25 (6.4)	3.0
		T-L	-100(290)	305(2103)	42(46)	0.047 (1.2)	CC	0.25 (6.4)	3.0
Plate: 1 in (25.4 mm) Thick	B,2	L-ST	70(294)	285(1965)	52(57)	0.083 (2.1)	Bend	0.25(6.4)	1.0
Forging: 8 in (203) Dia Con. Elec. Vac. Remote	C,3	L-T	70(294)	299(2062)	68(75)	0.129 (3.3)	Bend	0.5(12.7)	1.0
		T-L	70(294)	300(2068)	68(75)	0.128 (3.3)	Bend	0.5(12.7)	1.0
		T-L	-65(219)	---	54(59)	---	Bend	0.5(12.7)	1.0
	D,3	L-T	70(294)	280(1931)	83(91)	0.326 (8.3)	Bend	0.5(12.5)	1.0
		T-L	70(294)	280(1931)	77(85)	0.189 (4.8)	Bend	0.5(12.5)	1.0
G125									
Plate: 2.75 in (19 mm) Thick	E,4	L-T	70(294)	*296(2026)*	63(69)	---	(a)	---	---
		T-L	70(294)	*296(2020)*	60(66)	---	(a)	---	---
COMPOSITION									
	C	Mn	Si	P	S	Ni	Mo	Cr	Cr
A	0.03	0.26	0.07	0.003	0.007	18.00	4.77	9.16	0.70
B	0.03	0.02	0.06	0.003	0.010	18.53	4.64	8.89	0.69
C	0.003	0.002	0.01	0.002	0.004	18.51	4.84	9.11	0.15
D	0.014	0.05	0.02	0.004	0.004	18.25	4.79	8.87	0.10
E	0.01N	0.05M	0.051	0.005N	0.005M	18.5N	4.85N	9.0N	-
								0.75N	-
HEAT TREATMENT									
1.	1650F (1172K), 1 Hr, Air Cool; Age 850F (728K), 5 Hr								
2.	1500F (1089K), Age 900F (756K), 3 hr								
3.	Double Anneal, 1700F (1200K), 1 Hr, Fan Cool to 200F (367K), 1500F (1089K), 1 Hr, Fan Cool to 200F (367K), Aged 900F (756K), 6 hr								
4.	1507F (1083K), Air Cool; 895F (753K), 3 Hr, Air Cool								

* Tensile Ultimate Values

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S111, 18Ni: Maraging: 35G Grade

Table 17

Form	Compo- sition, Heat Treat- ment	Test Oriente- tion	Temp °F °K	Yield Strength $K_{\text{I}} \text{ (MN/m}^2)$	Typical K_{IC} $\text{KSI}\sqrt{\text{in}} \left(\text{MN/m}^{-2} \right)$	$2.5 \left(\frac{K_{\text{IC}}}{\sigma_y} \right)^2$			Specimen		
						Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Ref.	
Billet: 4 in (102mm) Sl. Cons. Elec. Vac. remelt	A, I	S-T	70(294)	338(2330)	37(40)	0.030 (0.8)	Bend 0.394(10)	0.394 (10)	0.15 (3.8)	17	
	S-L	S-L	70(294)	---	37(40)		Bend 0.394(10)	0.394 (10)	0.15 (3.6)		
	L-S	L-S	70(294)	334(2302)	36(39)	0.029 (0.7)	Bend 0.394(10)	0.394 (10)	0.15 (3.8)		

COMPOSITION

C	Mn	Si	P	S	Ni	Mo	Co	Al	T ₁	B	Zr
A	0.005	0.01	0.010	0.002	3.205	18.61	4.64	11.93	6.13	1.36	0.001 0.01

HEAT TREATMENT

1. Double Anneal, 1700F (1200K), 1 hr; 1500F (1089K), 1 hr; Aged 900F (750K), 8 hr

STAINLESS STEEL: 17-4 PH

Table 18

Form	Composition, Heat Treatment	Test Orientation	Temp. °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} kSI ^{3/2} (MN/m ^{-3/2})	2.5 $\left(\frac{K_{IC}}{\sigma_y}\right)^2$ in (mm)	Specimen			Ref
							Type	Thickness in (mm)	Width in (mm)	
Plate: 5.5 in (12.7 mm) Thick	B,1	L-T	200(367)	161(1110)	81(88)	0.633(16.1)	Bend	0.510(13)	1.0 (25.4)	---
	A,1	L-T	70(294)	168(1158)	46(50)	0.187(4.7)	Bend	0.510(13)	1.0 (25.4)	---
	A,1	T-L	70(294)	----	36(49)	----	Bend	0.510(13)	1.0 (25.4)	---
	B,1	L-T	70(294)	170(1172)	37(41)	0.118(3.0)	Bend	0.510(13)	1.0 (25.4)	---
	B,1	T-L	70(294)	----	40(44)	----	Bend	0.510(13)	1.0 (25.4)	---
	B,1	L-T	-50(228)	189(1303)	28(31)	0.055(1.4)	Bend	0.510(13)	1.0 (25.4)	---
	A,1	L-T	-50(228)	183(1262)	29(32)	0.063(1.6)	Bend	0.510(13)	1.0 (25.4)	---
	K,1	L-T	-100(200)	190(1310)	23(25)	0.037(1.0)	Bend	0.510(13)	1.0 (25.4)	---
	B,1	L-T	-100(200)	195(1344)	27(29)	0.048(1.2)	Bend	0.510(13)	1.0 (25.4)	---
Bar: 1/2 in (12.7 mm) Thick	C,1	L-T	70(294)	209(1441)	52(57)	0.177(4.5)	Bend	0.635(16.0)	0.635(15.1)	---
Bar: 3.3 in (83.5 mm) Thick Electroslag Remelted	H,3	L-R	70 (294)	186(1227)	48(53)	0.166(4.2)	Bend	0.75 (19.1)	1.5 (38.1)	0.75 (19.1) 120
Plate: 3.25 (83.6 mm) Dia	D,2	L-R	70(294)	168(1158)	85(93)	0.640(16.3)	Bend	1.0 (25.4)	2.0 (50.8)	.0 (25.4) 116

COMPOSITION

C	Mn	P	S	Si	Cr	Ni	Cu	Ta	Nb
A 0.036	0.24	0.018	0.016	0.58	15.8	1.31	3.46	0.02	0.21
B 0.037	0.28	0.019	0.013	0.60	15.7	4.37	3.29	0.01	0.21
C 0.038	0.22	0.018	0.018	0.64	15.7	4.27	3.46	0.01	0.21
D 0.030	0.28	-	0.55	15.6	4.52	3.39	-	0.24	
E 0.041	0.70	0.15	0.08	0.41	15.9	4.45	3.45	-	0.23

HEAT TREATMENT

1. 1400°F, (1033K) 1 1/2 Hr; Cool to 55°F (286K), Age 900°F (756K), 1 Hr

2. Iso 75 Condition

3. 900°F (750K), 1 Hr, (H900 Condition)

STAINLESS STEEL. 17-7 PH

Table 19

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K_{IC} $\text{ksi}\sqrt{\text{in}}$ ($\text{MN m}^{-\frac{3}{2}}$)	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen			Ref.
							Type	Thickness in (mm)	Width in (mm)	
Plate: 0.5 in (12.7 mm) Thick										
A,1	A,1	L-T	75(297)	164(1131)	66(72)	0.405(0.3)	Bend	0.5	(12.7) 1.0	(25.4) 0.574(9.5)
B,2	A,1	T-L	75(297)	153(1055)	64(70)	0.436(11.1)	Bend	0.5	(12.7) 1.0	(25.4) 0.203(1.9)
C,2	B,2	L-T	75(297)	185(1262)	63(69)	0.295(7.5)	Bend	0.5	(12.7) 1.0	(25.4) 0.268(6.8)
A,1	C,2	L-T	75(297)	176(1212)	67(74)	0.363(9.2)	Bend	0.5	(12.7) 1.0	(25.4) 0.236(6.0)
C,1	A,1	L-T	-50(228)	178(1227)	43(47)	0.146(3.7)	Bend	0.5	(12.7) 1.0	(25.4) 0.260(6.6)
D,1	C,1	L-T	-50(228)	155(1069)	51(56)	0.271(6.9)	Bend	0.5	(12.7) 1.0	(25.4) 0.223(5.7)
A,1	D,1	L-T	-50(228)	179(1234)	45(49)	0.159(4.0)	Bend	0.5	(12.7) 1.0	(25.4) 0.252(5.4)
A,1	E,2	L-T	-100(200)	180(1241)	45(47)	0.143(3.6)	Bend	0.5	(12.7) 1.0	(25.4) 0.206(5.2)
C,1	E,2	L-T	-100(200)	182(1241)	47(52)	0.170(4.3)	Bend	0.5	(12.7) 1.0	(25.4) 0.211(5.4)
D,1	F,2	L-T	-100(200)	190(1310)	45(49)	0.141(3.6)	Bend	0.5	(12.7) 1.0	(25.4) 0.234(5.9)
E,2	F,2	L-T	75(297)	164(1130)	56(61)	0.291(7.4)	Bend	0.223(5.7)	1.0	(25.4) 0.246(6.2)
E,2	G,2	L-T	-50(228)	165(1158)	38(42)	0.128(3.3)	Bend	0.223(5.7)	1.0	(25.4) 0.242(6.1)
E,2	H,2	L-T	-100(200)	175(1207)	32(35)	0.084(2.1)	Bend	0.223(5.7)	1.0	(25.4) 0.252(6.4)
F,2	H,2	L-T	-100(200)	186(1283)	47(52)	0.159(4.0)	Bend	0.197(5.0)	0.910(23.1)	0.263(6.7)
G,2	I,2	L-T	-103(200)	168(1158)	49(54)	0.212(5.4)	Bend	0.202(5.1)	0.930(23.6)	0.216(5.5)
H,2	I,2	L-T	75(297)	206(1420)	69(76)	0.297(7.5)	Bend	0.610(15.5)	0.616(16.6)	0.153(6.0)
Bar: 1 in (25.4 mm) Thick										
A	0.080	16.9	6.85	1.30	0.75	0.26	0.011	0.013		
B	0.080	16.9	7.85	1.30	0.75	0.26	0.011	0.013	HEAT TREATMENT	
C	0.078	16.9	7.38	1.36	0.62	0.25	0.025	0.008		
D	0.076	17.0	7.17	1.22	0.66	0.32	0.019	0.007		
E	0.073	16.7	7.20	1.05	0.72	0.45	0.028	0.005	1.	1400F (1033K), 1.5 hr; cool to SSSF (544K); Age 1050F (833K), 1.5 hr
F	0.069	17.2	7.29	1.08	0.63	0.56	0.017	0.012	2.	1750F (1228K), 10 min; cool to -110F (-173K), 3 hr; Age 950F (783K), 1 hr
G	0.077	16.7	6.56	1.11	0.78	0.50	0.032	0.013		
H	0.072	17.3	7.10	0.90	0.68	0.54	0.028	0.005		

STAINLESS STEEL: PH 15-7 Mo

Table 20

Form	Composition, Heat-Treatment	Test-Orienta-tion	Temp. °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/ln (MN m ⁻²)	2.5 $\frac{(K_{IC})^2}{\sigma_y}$ in (mm)	Specimen			Crack Length in (mm)	Ref.
							Type	Thickness in (mm)	Width in (mm)		
Plate: 0.5 in (12.7 mm) Thick	A,1	L-T	+200(367)	196(1551)	88(96)	0.504(12.8)	Bend	0.520(13.2)	1.0(25.4)	0.300(7.6)	7
	B,1	L-T	+200(367)	191(1517)	65(71)	0.290(7.4)	Bend	0.520(13.2)	1.0(25.4)	0.317(8.8)	
	A,1	L-T	70(294)	207(1427)	45(49)	0.118(3.0)	Bend	0.520(13.2)	1.0(25.4)	0.257(6.5)	
	B,1	L-T	70(294)	205(1400)	50(55)	0.152(3.9)	Bend	0.520(13.2)	1.0(25.4)	0.276(7.0)	
	A,2	L-T	70(294)	195(1344)	70(83)	0.569(14.4)	Bend	0.510(13.0)	1.0(25.4)	0.238(6.0)	
	A,2	L-T	70(294)	185(1262)	74(81)	0.409(10.4)	Bend	0.510(13.0)	1.0(25.4)	0.287(7.3)	
	A,2	L-T	-50(228)	203(1400)	53(58)	0.170(4.3)	Bend	0.510(13.0)	1.0(25.4)	0.381(9.7)	
	A,1	L-T	-50(228)	218(1503)	38(31)	0.041(1.0)	Bend	0.510(13.0)	1.0(25.4)	0.160(4.1)	
	B,2	L-T	-50(228)	184(1250)	46(50)	0.625(15.9)	Bend	0.510(13.0)	1.0(25.4)	0.249(6.8)	
	B,1	L-T	-100(200)	232(1630)	29(32)	0.039(1.0)	Bend	0.510(13.0)	1.0(25.4)	0.300(7.6)	
	B,2	L-T	-100(200)	205(1400)	46(50)	0.15(3.3)	Bend	0.510(13.0)	1.0(25.4)	0.282(7.2)	
	A,2	L-T	-100(200)	200(1379)	47(51)	0.138(3.5)	Bend	0.510(13.0)	1.0(25.4)	0.281(7.2)	
Bar: 1 in (25.4 mm) Thick	C,3	L-T	-5(297)	173(1193)	53(56)	0.256(6.0)	Bend	0.750(19.1)	0.750(19.1)	0.3 (7.6)	
	D,3	L-T	75(297)	178(1228)	50(55)	0.197(5.0)	Bend	0.750(19.1)	0.750(19.1)	0.256(6.0)	

COMPOSITION:

	C	Cr	Ni	Mn	Al	V _h	S ₁	P	S	HEAT TREATMENT:
A	0.070	15.3	"71	2.30	1.28	0.61	0.60	0.012	0.009	1.400F (1035K) 1.5 hr; Cool to 55F (286K); Age to 1650F (835K), 1 hr
B	0.070	15.1	7.51	2.37	1.19	0.52	0.26	0.018	0.012	1.400F (1035K) 1.5 hr; Cool to 55F (286K); Age to 1130F (880K), 1.5 hr
C	0.055	14.5	7.53	2.16	1.15	0.75	0.59	0.015	0.016	1.400F (1035K) 1.5 hr; Cool to 55F (286K); Age to 1080F (840K), 1.5 hr
D	0.060	14.6	7.43	2.21	1.22	0.74	0.58	0.019	0.013	1.400F (1035K) 1.5 hr; Cool to 55F (286K); Age to 1080F (840K), 1.5 hr

STAINLESS STEEL: PH13-8 NO and FV 520B

Table 21

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K_{IC}		2.5 $\left(\frac{K_{IC}}{\sigma_y}\right)^2$ in (mm)	Thickness in (mm)	Width in (mm)	Specimen	Crack Length in (mm)	Ref.	
					S ₁	Mn	P	Mo	Ni	Cr	Al	Cu	
<u>PH13-8N</u>													
Forging: 4.5 x 4.5 in (114.3 x 111.5 mm) bottile vacuum melted	A,1	L-L	70(204)	206(1120)	92(100)					0.500(12.7)	DIC	0.500(12.7)	16
		L-T	-110(191)	220(1579)	45(47)					0.088(2.2)	SEN	0.250(6.4)	1.0(25.4)
		T-L	-110(194)	227(1565)	41(35)					0.081(2.1)	SEN	0.250(6.4)	1.0(25.4)
Forging: 15 x 13 in (380.2 x 330.2 mm)	B-1	-110(194)	234(1544)	53(58)						0.146(3.7)	SEN	0.250(6.4)	1.0(25.4)
		L-L	-110(193)	218(1503)	57(62)					0.171(4.3)	SEN	0.250(6.4)	1.0(25.4)
Plate: 1.5 x 13 in (38.1 x 330.2 mm)	B-1	-110(194)	219(1510)	47(51)						0.115(2.9)	SEN	0.250(6.4)	1.0(25.4)
		T-L	-110(194)	226(1558)	47(51)					0.108(2.7)	SEN	0.250(6.4)	1.0(25.4)
Forging 9 x 9 in (229 x 229 mm)	B,2	L-TS	70(294)	205(1412)	89(98)					0.468(11.9)	CN	1.0(25.4)	8.6(21.8)
		L-S	-110(194)	219(1510)	42(46)					0.092(2.3)	CN	1.0(25.4)	8.6(21.8)
<u>FV520B</u>													
Bar: 6 in (152 mm) dia	C,2	L-R	70(294)	170(1172)	119(151)					1.225(3.1)	(a)	---	---
(a) Specimen in accordance with ASME Recommendations													
COMPOSITION													
	C	S ₁	Mn	S	P	Mo	Ni	Cr	Al	Cu	---	---	
A	0.042	0.02	0.02	0.001	0.003	2.06	8.07	12.58	1.11	-			
B	0.043	0.52	0.10	0.004	0.005	2.14	8.40	12.72	0.96	-			
C	0.078	0.63	1.66	0.025N	0.035M1.6N	5.4N	15.7N	-	1.6N	0.35N			

14. 1700C (1200F) 1 Hr, Air Cc 1; Refrigerated at -110F (194), 16 Hrs; Aged 1600F (811K), 1 Hr, Air Cool

1. 1921F (1523K), 150° C (112° C); 84H (725K), 3 Hr.

STAINLESS STEEL: AISI355, AFC: 77, AFC 266 (Sheet 1 of 2)

Form	Composition, Heat Treat- ment	Test Orien- tation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K_{IC} $\text{ksi}\sqrt{\text{in}}$ (MN/m)	$2\cdot\bar{s}\left(\frac{K_{IC}}{\sigma_y}\right)^2$ in (mm) $\text{ksi}\sqrt{\text{in}}$ (MN/m)	Specimen		Crack Length in (mm)	Ref
							Type	Thickness in (mm)	Width in (mm)	

Table 22

ANSYS	C.5 In (12.7 mm) Thick.	A,1	I-T	-50(228)	178(1227)	89(68)	0.505 (11.8)	Bend 0.775(19.7)	0.793(20.1)	0.22 (5.5)	7
Plate:	0.625 in (15.9 mm)	A,1	I-T	-100(200)	180(1241)	54(59)	0.225 (3.7)	Bend 0.775(19.7)	0.793(20.1)	0.22 (3.6)	50
Plate:	0.625 in (15.9 mm)	A,2	I-T	70(294)	201(1386)	74(81)	0.339 (8.6)	Bend 0.625(15.9)	1.0 (25.4)	...	50
Forging:	9x9 in (230 x 230 mm)	P,3	I-T	70(294)	167(1151)	63(69)	0.356 (9.0)	CC 1.0 (25.4)	9.0 (23.3)	1.5 (38.1)	
Forging:	9x9 in (230 x 230 mm)		I-T	-110(193)	24(70)	0.35 (8.9)	CC 0.375(9.5)	6.0 (15.2)	0.5 (12.7)		

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Bar: 3 in (76.2 mm) dia	C,4	L-R	70(294)	222(1531)	74(81)	0.278 (7.1)	Bend 0.48 (12.2)	1.5 ('8.1)	---	90
Air Heated		R-L	70(294)	210(1448)	62(76)	0.270 (6.9)	Bend 0.39 (1)	0.39 (1)		

Plate: 0.56 in (14.2 mm)
Thick:

117 / 60

ARC 200.
Plate: 0.55 in (14 mm) Thick.
D,7 L-T 75(297) 206(1420) 90(99)
0.477 (12.1) Read 0.5 (12.7) 1.5 (38.1) --- 114

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- | TREATMENT | 1. | 2. | 3. | 4. |
|--------------------------------------------------------------------------------------------------|----|----|----|----|
| 1740F (1206K), Water Quench; -100F (200K), 3 hr; Age 1000F (811K), 3 hr | 1. | | | |
| 1710F (1206K), 10 min; Temper 925F (770K), 3 hr | 2. | | | |
| 1935F (1325K), 0.5 hr; Oil Quench; -100F (200K), 3 hr; Temper 850F (728K), 2 hr; | | | | |
| Oil Quench; -100F (200K), 3 hr; 850F (728K), 1 hr; Air Cool | | | | |
| 1940F (1331K), 1 hr; Oil Quench; -100F (200K), 0.5 hr; Temper 800F (700K), 2 hr + 2 hr, Air Cool | 4. | | | |

Form	Composition, Heat treat- ment	Test orienta- tion	$\sigma_y^{\text{typ}}\text{ (N/mm}^2\text{)}$	Yield Strength $\sigma_F\text{ (N/mm}^2\text{)}$	Typical K_{IC} $\text{KN/m}^{3/2}$	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ $\text{KN/m}^{3/2}$	Specimen		
							Type	Thickness in (mm)	Width in (mm)

HEAT TREATMENT

5. 2000F (1367K), 1 hr, Oil Quench; -100F (200K), 0.5 hr; Temper 500F (533K), 2 hr, 10% Cold Reduction by Rolling; Temper 700F (644K), 2 hr + 2 hr, Air Cool.
6. Cold Rolled from 1.12 in (28.5 mm) Plate to 0.56 in (14.2 mm) in 5 stages with Intermediate Anneal, 1400F (1033K); 1800-1875F (1225-1297K), 1 hr, Oil Quench; -100F (200K), 0.5 hr, Temper 500F (533K), 2 hr + 2 hr
7. 2000F (1478K), 1 hr; 1900F (1511K), 1 hr, Oil Quench; -320F (76K), 1 hr, 1000F (811K), 2 hr + 2 hr

STLUL: ABS-C, ASIN A203 Grade A & D

Table 23

Fork	Compo- sition, Heat Treat- ment	Test Orient- ation	σ_{yf} (σ_{ek})	Yield Strength K_{SI} (MN/m^2)	Typical κ_{IC} $K_SIV\sqrt{\pi}$ (MN/m^{-3})	$2.5 \left(\frac{\kappa_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen			Ref
							Type	Thickness in (mm)	Width in (mm)	
A203-C Plate: 1 in (25.4 mm) Thick. Open Heart SI-Al Killed	A,1	L-T	70(294)	39(269)	43(47)	1.28 (32.6)	Bend 1.0	(25.4)	3.0 (76.2)	1.6 (40.6)
		L-T	-210(138)	60(414)	25(27)	0.177(4.5)	Bend 1.0	(25.4)	3.0 (76.2)	1.6 (40.6)
		L-T	-275(103)	94(618)	23(25)	0.098(2.5)	Bend 1.0	(25.4)	3.0 (76.2)	1.6 (40.6)
A203 Grade A Plate: 1.65 in (42 mm) Thick.	B,1	L-T	-200(141)	65(448)	51(56)	1.54 (39.1)	CT	1.645(41.8)	---	---
		L-T	-250(112)	77(531)	39(43)	0.641(16.3)	CT	1.645(41.8)	---	---
		L-T	-250(112)	90(621)	57(62)	1.002(25.5)	CT	1.645(41.8)	---	---
A203 Grade B Plate: 2 in (50.8 mm) Thick	B,2	L-T	-300(88)	---	41(45)	---	CT	1.645(41.8)	---	---
		L-T	-150(172)	61(521)	38(42)	0.970(24.6)	CT	2.0 (50.8)	---	---
		L-T	-250(144)	70(483)	37(41)	0.698(17.7)	CT	2.0 (50.8)	---	---
COMPOSITION										
	C	Mn	P	Si	Ni	Cr	Mo	Cu	Al	
A	0.20	0.60	0.009	0.016	0.023	0.07	0.01	0.03	0.357	
B	0.14	0.51	0.014	0.022	0.18	2.55	-	-	-	
C	0.11	0.45	0.010	0.023	0.23	3.35	-	-	-	
HEAT TREATMENT										
1.	1650F (1172K), 1 hr, Air Cool									
2.	Normalized									
3.	1650F (1172K), 2 hr, Water Spray Quenched; Tempered 1150F (894K), 2 hr, Air Cool									

STEEL: Low Strength: AISI 1045

Table 24

Form	Composition, Heat Treatment	Test orientation	Temp. of test	Yield Strength psi (MN/m^2)	Typical K_{IC}		Thickness in (mm)	Type	Width in (mm)	Crack Length in (mm)	Specimen Ref
					$\text{K}_{IC} \left(\frac{\text{MN/m}}{\text{in}^{-\frac{3}{2}}} \right)$	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$					
Plate: 4 in (101.6 mm) thick	A,1	L-T	25 (269)	39 (259)	46 (50)	3.5 (88.9)	WOL	4.0 (101.6)	10.22 (260)	4.08 (104)	45
		L-T	0 (256)	40 (276)	46 (50)	3.7 (84.1)	WOL	4.0 (101.6)	10.22 (260)	4.08 (104)	

COMPOSITION

	C	Mn	P	S	Si	Cr	Mo	Cu	V	T	
A	0.52	0.83	0.006	0.028	0.25	0.12	<0.10	0.03	0.29	<0.01	<0.01

HEAT TREATMENT

- Normalized; heated to 1700F (1200K), Air Cooled

STEEL: ASTM A216

Table 25

Form	Composition, Heat Treat- ment	Compo- sition, Heat Treat- ment	Test Origena- tion	Temp °F (°K)	Yield Strength KSI (tN/m ²)	Typical K_{IC} $\text{KSI}\sqrt{\text{in}} \left(\text{N/m}^{\frac{3}{2}}\right)$	$2.5 \left(\frac{K_{IC}}{\sigma_y}\right)^2$ in (mm)	Specimen		
								Type	Thickness in (mm)	Width in (mm)
A216 WCC Grade Casting: 20 x 20 x 48 in (508 x 508 x 219 mm)										
A, 1	-	-50(228)	55(379)	90(99)	6.694(170)	WOL	6 (152)	15.3 (389)	6.5 (165)	103
		-100(200)	61(421)	49(54)	1.613 (41)	WOL	2 (50.8)	5.1 (130)	2.08 (53)	
		-150(172)	67(462)	46(53)	1.283(32.6)	WOL	2 (50.8)	5.1 (130)	2.12 (54)	
		-200(144)	77(531)	33(36)	0.459(11.7)	WOL	2 (50.8)	5.1 (130)	2.11 (54)	

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	Al
A	0.24	1.15	0.008	0.011	0.44	0.37	0.09	0.02	0.06

HEAT TREATMENT

1. 1650F (1172K), 8 hr, Furnace Cool 600F (589K); 1125F (881K), Furnace Cool 600: (589K); 1750F (1220K), 8 hr, Furnace Cool to 1650F (1172K), Equalize; Accelerated Cooling to 200F (367K), Temper 1300F (922K), 8 hr, Air Cool

STEEL: ASTM A302B

Table 26

Form	Composition, Heat Treatment	Test Orientation	Temp. σ_F , σ_{UTS}	Yield Strength K_{S1} (MN/m ²)	Typical K_{IC} $f_{KIV\sqrt{n}}$ (MN/m ³)	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm) Type	Specimen			Ref
							Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 1 in (25.4 mm) Thick										
A,1	I-T	I-T	-150(172)	65 (448)	47 (52)	1.31 (33.2) Bend	1.0(25.4)	3.0(76.2)	1.6 (40.6)	10
	I-T	-200(144)	75 (503)	32 (35)	0.48 (12.2) Bend	1.0(25.4)	3.0(76.2)	1.6 (40.6)		
	I-T	-250(112)	89 (614)	25 (27)	0.197 (5.0) Bend	1.0(25.4)	3.0(76.2)	1.6 (40.6)		
	I-T	-321 (77)	123 (848)	23 (25)	0.087 (2.2) Bend	1.0(25.4)	3.0(76.2)	1.6 (40.6)		
Plate: 7 in (178 mm) Thick										
B,2	T-L	0 (256)	50 (345)	53 (58)	2.8 (71.3) WOL	4.0(101.6)	4.5(114.3)	2.0 (50.8)	11	
	T-L	-100(200)	63 (434)	45 (49)	1.28 (32.4) WOL	4.0(101.6)	4.5(114.3)	2.0 (50.8)		
	T-L	-200(144)	85 (586)	34 (37)	0.40 (10.2) WOL	2.0 (50.8)	2.25(57.2)	1.0 (25.4)		
	T-L	-321 (77)	140 (965)	26 (28)	0.006 (2.2) WOL	2.0 (50.8)	2.25(57.2)	1.0 (25.4)		
C,3	I-T	-25 (235)	61 (421)	76 (83)	3.88 (98.6) WOL	6.0(152.5)	8.63(219)	3.0 (76.2)	104	
	I-T	-200 (100)	82 (565)	42 (46)	0.656 (16.7) CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)		
	I-T	-250(112)	98 (676)	31 (34)	0.25 (6.4) CT	i.0 (25.4)	2.0 (50.8)	1.0 (25.4)		
D,2	I-T	-100(200)	60 (414)	40 (44)	1.11 (28.2) WOL	4.0(101.6)	4.5(114.3)	1.5 (38.1)	105	
	I-T	-200(144)	80 (552)	30 (33)	0.35 (8.9) WOL	2.0 (50.8)	2.25(57.2)	0.75(19.1)		
	I-T	-321 (77)	130 (896)	27 (30)	0.11 (2.7) WOL	4.0(101.6)	4.5(114.3)	1.5 (38.1)		
COMPOSITION										
A	C	Mn	P	S	S ₁	M _o	N _i	Cr	Cu	A1
A	0.19	1.40	0.017	0.014	0.16	0.49	0.03	0.97	0.03;	0.010
B	0.21	1.34	0.015	0.010	0.27	0.50	0.04	-	-	-
C	0.21	1.35	0.013	0.014	0.34	0.33	0.16	0.21	0.005	-
D	0.21	1.54	0.015	0.010	0.27	0.50	0.04	-	-	-

HEAT TREATMENT

1. 1650F (1172K), 70 minutes, Air Cool
2. Normalize 1650F (1172K), 7 hr, Fan Cool to 200F (367K), Air Cool; Stress Relieve 1200F (923K), 7 hr
3. 1650F (1172K), 7 hr; Stress Relieve 1200F (923K), 7 hr; Fan Cool to 800F (700K), Air Cool

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STEEL: Low Strength: ASTM A533 (Sheet 1 of 2)

Table 27

Form	Composition, Heat Treat- ment	Test Ori- ent- ation	σ_y^m $(^{\circ}K)$	Yield Strength KSI (MN/m^2)	Typical K_{IC} $KSIV\sqrt{in}$ ($MN/m^{3/2}$)	$2 \cdot 5 \left(\frac{K_{IC}}{\sigma_y^m} \right)^2$ $in (mm)$	Specimen			Ref
							Type	Thickness in (mm)	Width in (mm)	
ASTM A533 Grade B, Class 1										
Plate: 12 in (305 mm) Thick	A,1	L-T	50(284)	70(483)	*140(153)	10 (254)	CT	12 (305)	24 (610)	12 (305) 106
		L-T	25(269)	73(503)	*105(115)	5.17 (1.31)	CT	10 (254)	20 (508)	10 (254)
		L-T	0(256)	75(517)	*75 (83)	2.5 (63.5)	CT	6 (152)	12 (305)	6 (152)
		L-T	-25(235)	77(531)	* 57 (62)	1.37 (34.8)	CT	4 (102)	8 (203)	4 (.02)
		L-T	-100(200)	79(545)	* 48 (53)	0.92 (23.3)	CT	4 (102)	8 (203)	4 (102)
		L-T	-150(172)	86(593)	* 40 (44)	0.54 (13.7)	CT	4 (102)	8 (203)	4 (102)
		L-T	-200(144)	95(655)	* 38 (42)	0.40 (10.2)	CT	4 (102)	8 (203)	4 (102)
		L-T	-250(112)	111(765)	* 37 (41)	0.38 (7.1)	WOL	1 (25.4)	1.25 (31.8)	0.53 (13.5)
Plate: 12 in (305 mm) Thick	B,2	L-T	-200(144)	85(586)	33 (36)	0.38 (9.7)	WOL	1 (25.4)	1.25 (31.8)	0.5 (12.7) 107
		L-T	-250(112)	93(641)	29 (32)	0.24 (6.1)	WOL	1 (25.4)	1.25 (31.8)	0.5 (12.7)
Plate: 11.75 in (298 mm) Thick	C,3	L-T	-321 (77)	124(855)	26 (28)	0.11 (2.8)	WOL	1 (25.4)	1.25 (31.8)	0.5 (12.7)
		L-T	0(256)	77(531)	86 (95)	3.12 (79.2)	CT	4 (102)	8 (203)	4 (102) 106
		L-T	-50(228)	82(565)	75 (82)	2.09 (53.1)	CT	4 (102)	8 (203)	4 (102)
		L-T	-100(200)	85(586)	55 (69)	1.05 (26.7)	CT	3 (76.2)	6 (152)	3 (76.2)
		L-T	-200(144)	95(655)	45 (49)	0.56 (14.2)	CT	2 (50.8)	4 (102)	2 (50.8)
		L-T	-321 (77)	143(986)	38 (42)	0.18 (4.6)	CT	1 (25.4)	2 (50.8)	1 (25.4)
Plate: 6 in (152 mm) Thick	B,2	L-T	-150(172)	71(490)	38 (42)	0.716(18.2)	WOL	1 (25.4)	1.25 (31.8)	0.5 (12.7) 107
		L-T	-250(112)	102(702)	33 (36)	0.262(6.6)	WOL	1 (25.4)	1.25 (31.8)	0.5 (12.7)
		L-T	-320(78)	129(889)	34 (37)	6.174(4.4)	WOL	1 (25.4)	1.25 (31.8)	0.5 (12.7)

*Mid-Thickness Values

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STEEL: Low Strength: ASTM A533 (Sheet 2 of 2)

(Table 27 (Cont.))

Form	Composition, Heat Treat- ment	Test Orientation: ϕ_F θ_F	σ_{YF} (σ_K)	Yield Strength KSI (MN/m^2)	Typical K_{IC}		$2.5 \left(\frac{K_{IC}}{\sigma_{YS}} \right)^2$ in (mm) in (mm)	Specimen		
					K_{Ic}	$K_{Ic} \sqrt{\sigma_{YS}}$ (MN/m)		Type	Thickness in (mm)	Width in (mm)
COMPOSITION										
A	0.24	1.42	0.010	0.017	0.22	0.70	0.50	-	-	Al
B	0.18	1.25	0.024	0.025	0.24	0.52	0.51	0.15	0.29	-
C	0.23	1.35	0.012	0.025	0.26	0.50	0.48	-	-	0.025
HEAT TREATMENT										
1.	Normalize 1675 \pm 25F (1186 \pm 14K); Austenitize 1600 \pm 500F (1144 \pm 28K), 4 Hr, Water Quench; Temper 1225 \pm 25F (936 \pm 14K), 4 Hr, Furnace Cool; Stress Relieve 1150 \pm 25F (894 \pm 14K), 40 Hr, Air Cool									
2.	Austenitize 1650F (1172K), 1 Hr; Temper 1200F (922K). 8 Hr; Stress Relieve 1100F (894K), 24 Hr.									
3.	Normalize 1675 \pm 25F (1186 \pm 14K); Austenitize 1600 \pm 50F (1144 \pm 28K), 4 Hr, Water Quench; Temper 1225 \pm 25F (936 \pm 14K), 4 Hr, Air Cool; Stress Relieve 1135 \pm 25F (886 \pm 14K), Hold 25 Hr, Furnace Cool to 600F (539K), Air Cool									

STEEL: Low Strength: ASTM A542 and ASTM A543

Table 28

Form	Comp. ositon, Heat treat- ment	Res- tren- gth Orien- ta- tion	σ_{F} (kg/cm^2)	Yield strength σ_y (kg/cm^2)	KSI (lb/in^2)	Typical K_{IC} $(\text{MN/m}^{3/2})$	KSI $\sqrt{\text{in}}$ $(\text{MN/m}^{3/2})$	Specimen			
								$2 \cdot \frac{K_{IC}}{(\sigma_{vs})^{2/3}}$ in (mm)	Type	Thickness in (mm)	Width in (mm)
ASTM A542											
Plate: $\frac{1}{8}$ in (152 mm) Thick	A,1	L-T	-250(44)	218(81.4)	41 (45)	0.302(7.7)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	107
		L-T	-250(112)	132(91.0)	35 (38)	0.176(4.5)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	
Plate: 12 in (305 mm) Thick	A,1	L-T	-320 (73)	157(108.3)	29 (32)	0.31 (2.2)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	
		L-T	-200(141)	113(77.9)	69 (76)	0.932(23.7)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	
		L-T	-250(112)	128(87.5)	54 (38)	0.176(4.5)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	
		L-T	-320 (78)	156 (49.7 ₀)	30 (33)	0.992(2.3)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	
ASTM A543											
Plate: $\frac{1}{8}$ in (152 mm) Thick	B,2	L-T	-250(112)	116(80.0)	40 (44)	0.297(7.5)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	
		L-T	-320 (78)	141(97.2)	30 (7.5)	0.113(2.9)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	
Plate: 12 in (305 mm) Thick	B,2	L-T	-200(141)	110(75.8)	75 (82)	'16 (29.5)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	
		L-T	-250(112)	119(82.1)	50 (55)	0.441(17.7)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	
		L-T	-320 (78)	140(96.5)	35 (59)	0.156(4.0)	Wol.	1 (25.4)	1.25(31.8)	0.53(13.5)	

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
A	0.15	0.46	0.013	0.027	0.30	0.22	2.34	1.10	0.22	0.508
B	0.15	0.32	0.013	0.020	0.28	3.55	1.85	0.50	0.06	--

HEAT TREATMENT

1. 1750F (1228K), 1 hr; 1200F (922K), 8 hr; 1100F (867K), 24 hr.
2. 1575F (1130K), 1 hr, 1200F (922K), 8 hr; 1100F (867K), 24 hr.

STEEL: Intermediate Strength: AISI 1144 and HV 80

Table 29

Form	Composition, Heat Treatment	Test Orientation	Temp. °F (°K)	Yield Strength KSI (MN/m ²)	Typical K_{IC} $\text{kg}\sqrt{\text{m}}$	$2S \left(\frac{K_{IC}}{7 \text{ yrs}} \right)^2$ in (mm) Type	Specimen		
							Thickness in (mm)	Width in (mm)	Crack Length in (mm)
AISI 1144 Forging: 4 in (102 mm) Thick	A,1	L-T	75 (297)	78 (538)	61 (67)	1.53 (38.9) WOL	4 (102)	10.2 (259)	3.7 (94)
		T-L	0 (256)	78 (538)	52 (57)	1.11 (28.2) WOL	4 (102)	10.2 (259)	3.7 (94)
HV-80 Plate: 1 in (25.4 mm) Thick	B,2	L-T	-320 (78)	143 (986)	60 (66)	0.440 (11.2) Bend	1 (25.4)	3 (76.2)	1.6 (40.6) 10

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	V	Ti	Al
A	0.52	1.46	0.016	0.025	0.20	—	—	—	—	—	—
B	0.16	0.28	0.011	0.016	0.22	2.26	1.46	0.30	0.005	0.005	0.016

HEAT TREATMENT

1. 1550°F (1117°C), 6 hr, Oil Quench; 900°F (756°C), 6 hr, Furnace Cool.
2. 1660°F (1178°C), 92 minutes, Water Quench; 1500°F (978°C), 87 minutes, Water Quench.

STEPH: Intermediate Strength. ASTM A469 and Ni-Mo-V

Table 30

Form	Composition, Heat Treatment	Tensile Orientation ° ₁	Yield Strength ksi (N/mm ²)	Typical K_{IC} ksi \sqrt{in} (N/m ³)	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm) Type	Specimen			Ref
						Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
ASTM A469									
Forging: 31 in (787 mm) dia. 15 in (381 mm) Thick	A,1	L-R	50(283)	88(607)	120 (131)	4.65 (118)	WOL	4 (102)	10.2(259) 4 (102) 108
		L-R	0(256)	50(621)	70 (77)	1.51 (38.4)	WOL	2 (50.8)	5.1(130) 2 (50.8)
		L-R	-100(200)	95(655)	35 (38)	0.539 (8.6)	CT	1 (25.4)	2 (50.8) 1 (25.4)
		L-R	-200(144)	105(724)	27 (39)	9.165 (4.2)	CT	1 (25.4)	2 (50.8) 1 (25.4)
		L-R	-320 (78)	150(1034)	25 (27)	0.069 (1.8)	CT	1 (25.4)	2 (50.8) 1 (25.4)
Ni-Mo-V									
Forging: 38 in (965 mm) dia.	B,2	C-R	150(339)	80(552)	70 (77)	1.914 (48.6)	WOL	4 (102)	10.2(259) 3.6(91.4) 10.5
		C-R	70(294)	90(621)	50 (50)	0.772 (19.6)	WOL	3 (76.2)	7.7(196) 2.7(68.6)
		C-R	0(756)	95(655)	40 (44)	0.343 (11.3)	WOL	2 (50.8)	5.1(130) 1.8(45.7)
		C-R	-100(200)	100(690)	30 (33)	0.225 (5.7)	WOL	2 (50.8)	5.1(130) 1.8(45.7)
		C-R	-200(144)	110(758)	25 (27)	0.129 (3.3)	WOL	1 (25.4)	2.6 (6) 0.9(22.9)
		C-R	-320 (78)	140(965)	23 (25)	0.067 (1.7)	WOL	1 (27.4)	2.6 (6) 0.9(22.9)
COMPOSITION									
A	0.20	0.55	0.010	0.009	0.19	Si	Cr	Mn	V
B	0.23	0.50	0.005	0.010	0.21	3.4	0.08	0.30	0.07
IPAR REtREATMENT									
1.	1520F (1100K), 1180F (910K), 40 hr.								
2.	1475F (1075K), 20 hr, furnace Cool to 600F (589K), Hold 30 hr; 1640F (1166K), 30 hr, air Cool to 530F (550K), Hold 30 hr; temper 1150F (883K), 40 hr, furnace Cool to 400F (478K), Air Cool								

STEEL: Intermediate Strength: ASTM A470 and CR-Mo-V

Table 31

Form	Composition, heat treatment:	Test Orientation:	σ_{UTS} , ksi	σ_{UTS} , ksi	Yield Strength, ksi	K_{IC}	$2.5 \left(\frac{K_{IC}}{\sigma_{YS}} \right)^2$	Specimen		
								Thickness, in (mm)	Type	Width, in (mm)
ASTM A470 Forging: 15 in (381 mm) Dia.										
A-1	L-R	150(339)	88(607)	84(92)	2.28(57.9)	WOL	4 (.02)	10.2(259)	4 (102)	108
	L-R	75(197)	93(641)	50(55)	0.723(18.4)	WOL	4 (102)	10.2(259)	4 (102)	
	L-R	0(256)	95(655)	40 ()	0.443(11.3)	WOL	1 (25.4)	2.55(64.8)	1 (25.4)	
	L-R	-100(260)	105(724)	30 (33)	0.204(5.2)	WOL	1 (25.4)	2.55(64.8)	1 (25.4)	
	L-R	-260(144)	120(827)	25 (27)	0.109(2.8)	WOL	1 (25.4)	2.55(64.8)	1 (25.4)	
	L-R	-320(78)	160(1103)	23 (25)	0.052(1.5)	WOL	1 (25.4)	2.55(64.8)	1 (25.4)	
CR-Mo-V Forging										
B,-	L-R	70(294)	83(573)	69 (76)	1.738(44.1)	Bend	4 (102)	4 (102)	1 (25.4)	109
C,-	L-R	70(294)	80(552)	65 (71)	1.650(41.9)	Bend	6.7(170)	6.7(170)	1.6140.6)	

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	V
A	0.31	0.78	0.009	0.010	0.28	0.07	1.10	1.15	6.26
B	0.3	-	-	-	0.7	1.0	0.7	0.32	
C	0.3	-	-	-	0.6	1.2	1.1	0.37	

HEAT TREATMENT

1. 175°F (124K), 1240°F (944K), 40 hr.

STEEL: Intermediate Strength: ASTM A471 and Ni-Cr-Mo-V

Table 32

Form	Composition, Heat Treatment	Test Orientation	Yield strength, F _y (MN/m ²)	Typical K _{IC}		Thickness in (mm)	Type	Specimen			Crack length in (mm)	Ref
				K _{IC} (MN/m)	K _{IVR} (MN/m ^{-3/2})			Width in (mm)	Length in (mm)			
ASTM A471 Forging: 60 in (1524 mm) Dia.	A, I	I-R	(256)	115 (795)	155 (170)	4.54 (115)	WOL	4	(102)	10.2 (259)	4	(102)
		I-R	-100 (200)	125 (862)	100 (110)	1.6 (40.6)	WOL	5	(76.2)	7.7 (196)	3	(76.2)
		I-R	-200 (144)	140 (965)	60 (66)	0.459 (11.7)	WOL	3	(76.2)	7.7 (196)	3	(76.2)
		I-R	-320 (78)	180 (1241)	35 (38)	0.095 (2.4)	WOL	3	(76.2)	7.7 (196)	3	(76.2)
	B, I	I-R	200 (367)	140 (965)	150 (164)	2.86 (72.6)	CF	4	(162)	8 (203)	4	(102)
		I-R	70 (294)	155 (1069)	90 (99)	0.842 (21.4)	CF	2	(50.8)	4 (102)	2	(50.8)
		I-R	0 (256)	165 (1138)	65 (71)	0.388 (9.9)	CI	2	(50.8)	4 (102)	2	(50.8)
		I-R	-100 (200)	170 (1172)	58 (64)	0.291 (7.4)	CF	2	(50.8)	4 (102)	2	(50.8)
		I-R	-200 (144)	180 (1241)	45 (17)	0.145 (3.6)	CF	2	(50.8)	4 (102)	2	(50.8)
		I-R	-320 (78)	205 (1413)	25 (25)	0.031 (0.8)	CF	2	(50.8)	4 (102)	2	(50.8)
Ni-Cr-Mo-V Disc Forging	C,-	I-R	70 (294)	109 (752)	90 (99)	1.7 (43.2)	Bend	5.66 (144)	5.66 (144)	1.3 (33)	109	
		I-R	-104 (198)	117 (807)	58 (64)	0.614 (15.6)	Bend	3 (76.2)	3 (76.2)	0.9 (22.9)		
	D,-	I-R	-71 (213)	117 (807)	83 (91)	1.258 (3.2)	Bend	5 (127)	5 (127)	1.1 (27.9)		
COMPOSITION												
A	0.21	0.28	0.005	0.012	0.04	3.51	1.64	0.39	0.21			
B	0.27	0.33	0.009	0.009	0.04	5.48	1.57	0.40	0.13			
C	0.28	-	-	-	-	2.4	0.8	0.5	0.1			
D	0.35	-	-	-	-	3.3	1.6	0.6	0.15			
HEAT TREATMENT												
1.	1550F (1117K), 1090F (862K), 40 hr.											

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SHEET: Intermediate Strength: ASTM A517-F and HY130

Table 33

Form	Composition Re- duc- tion in per- cent	Yield Strength		Typical K_{IC} $\left(\frac{K_{IC}}{\sigma_y} \right)^2$	$\frac{E \cdot S}{K \sqrt{I_E}} \left(\frac{MN/m}{MN/m^2} \right)$	Specimen		
		σ_y (MN/m^2)	F_{y4} (MN/m^2)			Width in (mm.)	Crack length in (mm.)	
ASTM A517-F								
Plate: 1 in (25.4 mm) Thick, Open hearth Melted	A, 1	1-1	-100 (200)	127 (876)	75 (82)	0.87 (22.1)	Bend 1 (25.4) 3 (76.2) 1.6 (46.1) 10	
		1-1	-165 (16.2)	135 (917)	53 (58)	0.397 (10.1)	Bend 1 (25.4) 3 (76.2) 1.6 (40.1)	
		1-1	-200 (11.1)	139 (958)	47 (51)	0.286 (7.5)	Bend 1 (25.4) 3 (76.2) 1.6 (40.1)	
HY130								
Plate: 1 in (25.4 mm) Thick, Air Melted	B, 2	1-1	-250 (11.2)	165 (1138)	80 (88)	0.588 (14.9)	Bend 1 (25.4) 3 (76.2) 1.6 (40.1) 10	
		1-1	-320 (7.8)	180 (1310)	15 (17)	0.128 (5.3)	Bend 1 (25.4) 3 (76.2) 1.6 (40.1) 10	
COMPOSITION								
	C	Mn	P	S	Si	Ni	Cr	Mo
A	0.17	0.78	0.012	0.017	0.25	0.56	0.42	0.036
B	0.11	0.85	0.069	0.007	0.25	0.58	0.58	0.06
HEAT TREATMENT								
1.	1660° (1178K), 70 minutes, water quench; 1230° (939K), 90 minutes, water quench.							
2.	1560° (1089K), 93 minutes, water quench; 116° (890K), 93 minutes, water quench.							

1. 1660° (1178K), 70 minutes, water quench; 1230° (939K), 90 minutes, water quench.
 2. 1560° (1089K), 93 minutes, water quench; 116° (890K), 93 minutes, water quench.

TITANIUM-2.5 Sn Alloy: SAI-2.5 Sn

Table 34

Form	Composition, Heat Treat- ment	Test Oriente- tion	Temp of σ_y	Yield Strength, KSI (MN/m^2)	Typical r_{IC} (MN/m)	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen			Ref.
							Type	Thickness in (mm)	Width in (mm)	
Plate: 0.5 in (12.7 mm) Thick (ELI)	A,1	L-T	-320(78)	175(120*)	65(71)	0.345(8.8)	Bend	0.250(6.4)	0.500(12.7)	---
		T-L	-320(78)	171(1179)	50(55)	0.214(5.43)	Bend	0.250(6.4)	0.500(12.7)	---
		T-T	-423(21)	205(1413)	55(60)	0.180(4.6)	Bend	0.250(6.4)	0.500(12.7)	---
		T-L	-423(21)	209(1441)	52(57)	0.155(3.9)	Bend	0.259(6.4)	0.500(12.7)	---
Plate: 0.5 in (12.7 mm) Thick (Commercial Grade)	B,1	L-T	-320(78)	203(1400)	26(28)	0.041(1.0)	Bend	0.255(6.4)	0.500(12.7)	---
		T-L	-320(78)	204(1407)	50(55)	0.150(3.8)	Bend	0.250(6.4)	0.500(12.7)	---
		L-T	-423(21)	233(1606)	25(27)	0.029(0.7)	Bend	0.250(6.4)	0.500(12.7)	---
Plate: 0.8 in (20.3 mm) Thick (ELI)	C,2	T-L	-320(78)	173(1193)	62(68)	0.321(8.2)	Bend	0.400(10.2)	0.75 (19.0)	0.375(9.5)
		T-L	-423(21)	187(1289)	65(61)	0.302(7.7)	Bend	0.400(10.2)	0.75 (19.0)	0.375(9.5)

COMPOSITION

	Al	Sn	Fe	N	C	Mn	Mg	II	II	N
A	5.0	2.6	0.16	0.01	0.023	0.006	---	0.001	0.086	0.010
B	5.1	2.3	0.34	0.015	0.023	0.006	---	0.017	0.017	0.015
C	5.1	2.50	0.19	---	0.02	---	0.01	940ppm	940ppm	70ppm

HEAT TREATMENT

1. 1500F (1089K) Furnace Cooled
2. 1500F (1117K), 16 hr, Furnace Cooled

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TITANIUM, Near α Alloys: IMI 679, IMI 685, 8Al-1Mo-1V, 6Al-2Sn-4Zr-2Ti (Sheet 1 of 2) Table 35

Form	Composition, heat treatment	Test orientation	Temp, °F	Yield Strength KSI (MN/m ²)	Typical K _{IC} $\left(\frac{K_{IC}}{\sigma_y} \right)^2$	2.5 $\left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm) KSI \sqrt{in} (MN/m ^{-3/2})	Specimen			Crack length in (mm)	Ref
							Type	Thickness in (mm)	Width in (mm)		
IMI 679, Forging: 0.625 in (15.9 mm) Thick 8 Processed 2100F (1422K)	A,1 (a)	70(294)	141(979)	31(34)	0.119(3.0)	Bend	0.5(12.7)	---	---	22	
Forging: 0.625 in (15.9 mm) Thick α + β Processed 3675F (1186 K)	A,1 (a)	70(294)	153(1055)	26(28)	0.072(1.8)	Bend	0.5(12.7)	---	---		
Forging: 1.25 in (31.8 mm) Thick 8 Faxed 1800F (1255K)	E,5 (a)	70(297)	135(931)	57(62)	0.445(11.3)	Bend	0.5(12.7)	---	---	92	
IMI 685 Bar: 3.75 in (95 mm) Dia. 8 Worked	E,6 (a)	I-C 70(294)	137(941)	64(70)	0.546(13.9)	(b)	---	---	---	121	
Plate: 3.7 in (93 mm) Thick, α + β Worked	E,7 (a)	L-C 70(294)	143(884)	55(66)	0.370(9.4)	(b)	---	---	---		
Plate: 3.7 in (93 mm) Thick, α + β Worked	E,8 (a)	S-T 70(294)	130(896)	56(61)	0.464(11.8)	(b)	---	---	---		
1-8Al-3Mo-1V Plate: 1 in (25.4 mm) Thick	E,2 (a)	I-T 70(294)	138(951)	67(74)	0.589(15.0)	SEN	0.87(22.4)	5 (127)	1.7(43.2)	82	
Forging: 0.625 in (15.9 mm) Thick 8 Processed 2100F (1422K)	C,3 (a)	70(294)	126(868)	57(63)	0.512(13.0)	Bend	0.5(12.7)	---	---	22	
Forging: 0.625 in (15.9 mm) Thick α + β Processed 1800F (1255K)	C,3 (a)	70(294)	145(966)	34(37)	0.167(4.3)	Bend	0.5(12.7)	---	---		
6Al-2Sn-4Zr-2Ti Forging: 0.75 in (19.1 mm) Thick 8 Processed 2100F (1422K)	D,4 (a)	70(294)	146(1006)	52(57)	0.377(8.1)	Bend	0.5(12.7)	---	---	22	
Forging: 0.625 in (15.9 mm) Thick α + β Processed 1750F (1228K)	D,4 (a)	70(294)	160(103)	32(35)	0.100(2.5)	Bend	0.5(12.7)	---	---		

TITANIUM, Near α Alloys: IMI 679, Ti-685, 8Al-1Mo-IV, 6Al-2Sn-4Zr-2Mo (Sheet 2 of 2) Table 35 (Cont.)

From	Composition, Heat Treatment				Test temp., °F (°C)	Yield Strength, ksi (MN/m²)	KSI (MN/m²)	Typical K_{IC} ² , ksi \sqrt{in} (MN/m ^{3/2})	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm) ³	Spec. in (mm), W-dash		Crack length in (mm)	Ref
	Al	Mo	V	Sn						Thickness	Type	Width	
A	2.3	0.9	-	11.1	5.0	0.06	0.21	0.023	-	-	-	-	-
B	7.96	0.92	1.0	0.15	-	0.12	0	0.049	0.07	0.013	5	0.006	-
C	7.7	1.1	1.0	-	-	0.07	-	0.022	-	-	-	-	-
D	5.0	2.0	-	2.1	3.9	0.06	-	0.024	-	-	-	-	-
E	6.06	0.5	-	-	-	0.18	-	0.15	-	-	-	0.005	-
F	2.25N	1.0N	-	11.0N	5.0N	0.12N	0.12N	0.04M	0.10N	-	-	-	-

HEAT TREATMENT

1. 1650F (1172K), Water Quench, 930F (772K), 24 hr, Air Cool
2. 1800F (1255K), 1 hr, Water Quench; 1100F (867K), 2 hr, Air Cool
3. 1850F (1283K), 1 hr, Water Quench; 1100F (867K), 8 hr, Air cool
4. 1775F (1242K), 1 hr, Water Quench; Aged 1100F (867K), 8 hr, Air Cool
5. 1655F (1198K), 1 hr, Air Cool; 930F (772K), 24 hr, Air Cool
6. 1291F (973K), Air Cool
7. 1922F (1223K), Gil Quench; 1021F (823K), 24 hr
8. 1851F (1273K), Air Cool; 931F (773K), 24 hr

TITANIUM: α - β Alloys: INI 550, INI 551, 6Al-2Mo (Sheet 1 of 2)

Table 36

Form	Composition, heat treatment	Test orientation	Temp., °F.	Yield strength KSI (tN/m^2)	Typical K_{IC} $K_{IV}\sqrt{\text{in}}$ ($\text{MN/m}^{3/2}$)	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen		
							Type	Thickness in (mm)	Width in (mm)
INI 550 Plate: 0.63 in (16 mm) Thick	A,1	T-I.	70(294)	169(1103)	74(81)	0.535(13.6)	Bend	0.5(12.7)	1.5(38.1)
	A,2	T-L	70(294)	177(1220)	49(54)	0.192(4.9)	4 Pt Bend	0.5(12.7)	1.5(38.1)
Plate: 1.25 in (31.8 mm) Thick	B,3	L-T	70(294)	142(978)	77(85)	0.735(18.7)	(a)	---	---
Plate: 2.13 in (54 mm) Thick	C,4	L-T	70(294)	170(1174)	59(65)	0.301(7.6)	(a)	---	---
Bar: 3.37 x 0.625 in (85.7 x 15.9 mm)	D,5	L-T	70(294)	137(946)	61(67)	0.49b(12.6)	(n)	---	---
	D,5	T-L	70(294)	135(931)	60(65)	0.494(12.5)	(a)	---	---
Bar: 2 x 3.5 in (50.8 x 89.9 mm)	E,7	L-S	70(294)	135(931)	59(64)	0.494(12.5)	(a)	---	---
	D,6	T-L	70(294)	137(945)	52(57)	0.360(9.1)	(a)	---	---
	T-L	70(294)		156(1034)	34(37)	0.128(3.3)	(a)	---	---
	T-S	70(294)		150(1034)	44(49)	0.215(5.5)	(a)	---	---
	S-L	70(224)		121(831)	49(54)	0.410(10.4)	(a)	---	---
	S-T	70(294)		121(834)	33(36)	0.186(4.7)	(a)	---	---
Forging: 5 x 1.48 in (127 x 36 mm) Thick	F,2	L-T	70(294)	136(938)	48(53)	0.311(7.9)	(a)	---	---
Forging: 5.1 in (130 mm) Square	K,-	S,T-L.	70(294)	136(938)	62(68)	0.520(13.2)	Bend	0.5(12.7)	1 (25.4) 0.54(13.8)
	K,-	S,T-S,T	70(294)	136(938)	48(53)	0.311(7.9)	Bend	0.5(12.7)	1 (25.4) 0.51(13)
Extrusion	G,7	-	70(294)	137(945)	53(58)	0.374(9.5)	(a)	---	---
INI 551 Bar: 1 in (25.4 mm) Square	H,7	L-T,S	70(294)	172(1195)	31(34)	0.080(2.0)	(a)	---	---
Extrusion	I,7	L-R	70(294)	166(1143)	40(44)	0.145(3.7)	(a)	---	---
	I,9	L-R	70(294)	158(1086)	51(56)	0.260(6.6)	(a)	---	---
6Al-2Mo Plate: 3 in (76.1 mm) Thick b Forged 2050F (1354K)	J,10	T-I.	70(294)	113(779)	100(110)	1.958(49.7)	Bend	3 (76.1) 6 (152)	3 (76.1) 81

(a) Specimen in Accordance with ASTM Recommendations

TITANIUM: α - β Alloys: IMI 550, IMI 551, 6Al-2Mo (Sheet 2 of 2)

Table 36 (Cont.)

Form	Composition, Heat-Treatment			test orientation $\sigma_{t \times \theta}$	yield strength K_{YS} (N/mm^2)	Typical K_{IC} $\text{KSI}\sqrt{\text{in}}$ ($\text{MN/m}^{3/2}$)	$Z_{S(\frac{K_{IC}}{\sigma_{YS}})^2}$ in (mm)	Specimen		
	Al	Mn	Sn					Thickness in (mm)	Type	Width in (mm)
COMPOSITION										
A	4.0	4.3	2.1	0.09	0.50	-	0.005	-	-	-
B	4.125	4.08	2.04	-	0.47	-	0.002	0.185	-	-
C	4.08	3.99	2.10	-	0.48	-	0.001	0.19	-	-
D	4.0	3.95	2.19	0.12	0.54	-	0.003	-	-	-
E	4.0%	4.0%	2.0%	0.2%	0.4%	-	0.15%	-	-	-
F	4.02	4.03	2.10	-	0.46	-	0.002	0.14	-	-
G	4.11	3.95	2.00	-	0.53	-	0.003	0.2	-	-
H	3.93	4.02	4.10	-	0.48	-	0.004	0.19	-	-
I	4.08	3.89	3.97	-	0.55	-	0.001	0.2	-	-
J	6.2	2.0	-	0.4	-	0.25	-	0.06	0.006	-
K	4.01	3.95	2.09	0.04	0.51	-	0.003	-	-	-

HEAT TREATMENT

1. 1650F (1173K), 0.5 hr, Air Cool; 800F (700K), 24 hr, Air Cool; 932F (773K), 24 hr, Air Cool
2. 1650F (1173K), 0.5 hr, Air Cool; Cold Rolled 20% Reduction; 932F (773K), 24 hr, Air Cool
3. 1786F (1248K), 1 hr, Water Quench; 1650F (1173K), 4 hr, Air Cool; 931F (773K), 24 hr, Air Cool
4. 1650F (1173K), 2 hr, Air Cool; 931F (773K), 24 hr, Air Cool
5. 1795F (1253K), 1 hr, Air Cool; 1650F (1173K), 1 hr, Air Cool; 931F (773K), 24 hr, Air Cool
6. 1795F (1253K), 1 hr, Air Cool; 1597F (1143K), 1 hr, Air Cool; 931F (773K), 24 hr, Air Cool
7. 1650F (1173K), Air Cool; 931F (773K), 24 hr
8. 1650F (1173K), 6 hr, Air Cool; 931F (773K), 24 hr
9. 2957F (1243K), Air Cool; 1650F (1173K), Air Cool; 931F (773K), 24 hr
10. 1750F (1228K), 3 hr, Air Cool; 1100F (867K), 4 hr, Water Quench

LANTUM: α - β Alloy: IMI 680

Table 37

Form	Composition, Heat Treatment	Test Orientation	Temp (°F)	Yield Strength KSI (MPa)	Typical K_{IC} $\text{KSI}\sqrt{\text{in}}$	$2.5 \left(\frac{K_{IC}}{C_y} \right)^2$ in (MN m^{-3})	Specimen			Crack Length in (mm) Ref.
							Type	Thickness in (mm)	Width in (mm)	
Sqr: 2 x 1.3 in (50.8 x 33 mm)	A,1	L-T	70(294)	179(1254)	29(32)	0.966(1.7)	(a)	---	---	6.5
Forging: 0.75 in (19mm) Thick Disc	A,2	---	70(294)	140(965)	59(65)	0.444(11.3)	(a)	---	---	5.6
	A,3	---	70(294)	143(984)	50(55)	0.306(7.8)	(a)	---	---	---
	A,4	---	70(294)	159(1093)	40(44)	0.158(4.0)	(a)	---	---	---
	A,5	---	70(294)	163(1123)	32(35)	0.96(2.4)	(a)	---	---	---
	A,6	---	70(294)	174(1200)	19(21)	0.29(0.76)	(a)	---	---	---
	A,7	---	70(294)	192(1521)	15(16.5)	0.15(0.39)	(a)	---	---	---
Forging: 4 x 6.2 in (102 x 158 mm) Thick	A,8	L-T	70(294)	166(1145)	45(49)	0.184(4.7)	Bend	0.50(12.7)	1.5(38.1)	0.35(8.9)
	A,-	T-S	70(294)	158(951)	69(76)	0.625(4.7)	Bend	0.5(12.7)	1.0(25.4)	---
		T-S	70(294)	150(1034)	54(59)	0.333(8.5)	Bend	0.5(12.7)	1.0(25.4)	---

(a) Specimen in accordance with ASTM Recommendations

COMPOSITION

A	Al	Mo	Sn	Fe	Si	H
2.25N	4.0N	11.0N	0.2N	0.2N	0.013N	

HEAT TREATMENT

1. 1471-1501F (1073-1123K); 931F (773K), 24 hr, Air Cool
2. Forged at 1831F (1273K); 1606F (1148K), Furnace Cool; 937F (793K), 24 hr, Air Cool
3. Forged at 1596F (1198K); 1606F (1148K), Furnace Cool; 962F (793K), 24 hr, Air Cool
4. Forged at 1831F (1273K); 1498F (1088K), Water Quench; 937F (793K), 24 hr, Air Cool
5. Forged at 1696F (1198K); 1498F (1085A), Water Quench; 962F (793K), 24 hr, Air Cool
6. Forged at 1606F (1148K); 1606F (1148K), Water Quench; 937F (793K), 24 hr, Air Cool
7. Forged at 1831F (1273K); 1606F (1148K), Water Quench; 937F (793K), 24 hr, Air Cool
8. 1430F (1083K), 1 hr, Water Quench; 930F (772K), 24 hr, Air Cool

TITANIUM: α - β Alloys: 4Al-3Mo-IV, 7Al-2.5Mo, 7Al-4Mo

Table 38

Form	Composition, Heat Treatment	Test orientation	$\sigma_{UTS} \cdot 10^3$, lb/in ²	Yield strength KSI (10 ³ lb/in ²)	Typical K_{IC} $KSIV\sqrt{in} \left(\frac{MN/m}{in^{3/2}} \right)$	$2.5 \left(\frac{K_{IC}}{\sigma_{YS}} \right)^2$ in (mm)	Specimen			
							Type	Thickness in (mm)	Width in (mm)	
Ti-4Al-3Mo-IV										
Plate: 0.5 in (12.7 mm) Thick	A,1	I-T	70(294)	155(1069)	72(78)	0.539(13.7)	Bend	0.5 (12.7)	1.5(38.1)	0.5(7.6)
	A,2	I-T	70(294)	161(1110)	65(69)	0.382(9.5)	Bend	0.5 (12.7)	1.5(38.1)	0.3(7.6)
Plate: 0.5 in (12.7 mm) Thick	A,3	T-I	70(294)	175(1207)	66(72)	0.356(9)	Bend	0.5 (12.7)	1.5(38.1)	0.3(7.6)
Forging: 0.625 in (15.9 mm) Thick B Processed 2100F (1422K)	B,3	(a)	70(294)	146(1007)	49(53)	0.282(7.2)	Bend	0.5 (12.7)	---	---
Ti-7Al-2.5Mo										94
Plate: 0.5 in (12.7 mm) Thick	E,7	T-I	70(294)	152(1048)	52(57)	0.293(7.4)	Bend	0.5 (12.7)	1.5(38.1)	0.35(8.9)
	E,8	T-I	70(294)	136(938)	65(71)	0.571(14.5)	Bend	0.5 (12.7)	1.5(38.1)	0.35(8.9)
Ti-7Al-4Mo										94
Plate: 0.5 in (12.7 mm) Thick	D,6	T-I	70(294)	145(1006,	33(36)	0.129(3.3)	Bend	0.5 (12.7)	1.5(38.1)	0.3 (7.6)
Forging: 0.625 in (15.9 mm) Thick B Processed 2100F (1422K)	C,4	(a)	70(294)	155(1069)	41(45)	0.175(4.4)	Bend	0.5 (12.7)	---	---

(a) Test orientation is not specified, but loading and crack propagation directions are in a plane where maximum grain flow is approximately radially symmetric.

COMPOSITION	Al	Mn	V	σ_{UTS}	σ_{YS}	σ_c	σ_u	σ_0	N
A	4.5	3.3	1.0	0.10	0.03	0.006	0.11	0.000	
B	4.1	3.1	1.1	0.08	0.02	-	-	-	
C	6.9	4.0	-	0.12	0.023	-	-	-	
D	6.9	3.7	-	0.15	0.02	0.005	0.15	0.007	
E	6.8	2.4	-	0.04	0.02	0.004	0.06	0.008	

HEAT TREATMENT

1. 1875F (1297K), 1 hr, Air Cool; 1725F (1214K), 1 hr, Water Quench; 1050F (839K), 8 hr, Air Cool
2. 1800F (1255K), 1 hr, Water quenched; Aged 1100F (867K), 8 hr, Air Cooled
3. 1725F (1214K), 1 hr, Water Quench; 1050F (839K), 4 hr, Air Cool
4. 1750F (1228K), 1 hr, Water Quench; 1050F (839K), 4 hr, Air Cool
5. 1875F (1297K), 1 hr, Water Quench; 1100F (867K), 8 hr, Air Cool
6. Mill Annealed
7. 1800F (1255K), 0.5 hr, Water Quench; 1100F (867K), 8 hr, Air Cool
8. Mill Annealed; hot rolled 50°. Reduction at 1750F (1228K)

TITANUM. "S" Alloy: GAl-4V (Sheet 1 of 2)

Table 39

TITANIUM, $\alpha\beta$ Alloy: 6Al-4V (Sheet 1 of 2)										Table 39				
Form	Composition, Heat Treatment (α ; Processed)	Test Orientation	Temp $^{\circ}\text{F}$	Temp $^{\circ}\text{K}$	Yield Strength ksi (MN/m^2)	Typical K_{IC} $\text{ksi}/\sqrt{\text{in}}$ $\left(\frac{3}{\text{MN m}}\right)$	Specimen			Crack Length in (mm)	Ref.			
							2.5 $\left(\frac{K_{IC}}{\sigma_{ys}}\right)^2$	Thickness in (mm)	Type	Width in (mm)				
Plate: 0.5 in (12.7 mm) Thick (α ; Processed)	A,1	L-T	75(297)	148(1020)	46(50)	0.240(6.1)	Bend	1.0	(25.4)	1.0 (25.4)	0.290 (7.4)	7		
		T-L	75(297)	---	42(46)	---	Bend	1.0	(25.4)	1.0 (25.4)	0.3 (7.6)			
		L-T	-50(-228)	---	46(50)	---	Bend	1.0	(25.4)	1.0 (25.4)	0.3 (7.6)			
		L-T	-100(200)	185(1276)	47(51)	0.161(4.1)	Bend	1.0	(25.4)	1.0 (25.4)	0.26 (6.6)			
		B,1	75(297)	148(1020)	48(52)	0.263(6.7)	Bend	1.0	(25.4)	1.0 (25.4)	0.303 (7.7)			
		L-T	-50(-228)	177(1220)	53(58)	0.224(5.7)	Bend	1.0	(25.4)	1.0 (25.4)	0.267 (6.8)			
		L-T	-100(200)	173(1193)	54(59)	0.246(5.2)	Bend	1.0	(25.4)	1.0 (25.4)	0.208 (5.3)			
Plate: 0.75 in (19.1 mm) Nominal Thickness	C,2	L-T	75(297)	133(916)	75(82)	0.792(20.1)	Bend	0.781(19.8)	1.5 (38.1)	0.5 (7.6)	20			
Plate: 1.0 in (25.4 mm) Thickness (α ; Processed)	D,5	T-L	75(297)	150(1034)	45(49)	0.225(5.7)	Bend	0.9	(22.9)	1.8 (45.8)	0.45 (11.4)	4		
		T-L	-321(-78)	227(1565)	36(39)	0.063(1.6)	Bend	0.9	(22.9)	1.8 (45.8)	0.45 (11.4)			
Plate: 0.5 in (12.7 mm) Thick	E,3	L-T	70(294)	148(1034)	70(77)	0.56 (14.2)	Bend	0.5	(12.7)	1.5 (38.1)	---	34		
Forging: 0.625 in (15.9 mm) Thick a Processed 2100F (1422K) $\alpha+\beta$ Processed 1750F (1228K)	F,4 (b)	75(297)	146(1007)	60(65)	0.422(10.7)	Bend	0.5	(12.7)	---	---	22			
					46(50)	0.235(6.0)	Bend	0.5	(12.7)	---	---			
Blockforging: 1.0 in (25.4 mm) Thick	J,6	L-T	70(294)	150(1034)	61(66)	0.413(10.5)	Bend	0.55 (14)	1.02 (26)	0.55 (14)	23			
		T-L	70(294)	148(1020)	55(60)	0.345(8.8)	Bend	1.0	(25.4)	2.0 (50.8)	1.0 (25.4)			
Forging: 3.0 in (76.1 mm) Thick	G,2	T-L	150(339)	127(875)	78(86)	0.942(23.9)	WOL	2.0	(50.8)	6.2 (15.8)	1.8 (4.6)	11		
		L-T	75(297)	110(966)	61(89)	0.837(21.3)	WOL	2.0	(50.8)	2.25(57.2)	0.5 (12.7)			
Bar: 2.26 x 1.2 in (57.5 x 30.5 mm)	H,7	L-T	-75(214)	159(1097)	68(75)	0.457(11.6)	WOL	2.0	(50.8)	6.2 (15.8)	1.8 (4.6)			
		T-S	70(294)	128(883)	71(78)	0.769(19.5)	(a)	---	---	---	---	63		
Bar: 2 in (50.8 mm) Dia	I,8	L-S	70(294)	140(968)	58(55)	0.429(10.9)	(a)	---	---	---	---			
	J,5	T-S	70(294)	147(1011)	55(60)	0.350 (8.9)	Bend	0.5	(12.7)	1.0 (25.4)	---	60		

TITANIUM, α - β Alloy: 6Al-4V (Sheet 2 of 2)

Table 39 (Cont.)

Form	Composition, Heat Treatment	Pest Orientation	σ_{F} σ_{U}	yield strength K_{SI} (N/m^2)	Typical K_{IC} $KSI\sqrt{In} \left(MN/m^{-3} \right)$	$2.5 \frac{(K_{IC})^2}{(\sigma_{ys})}$ in (mm)	Thickness Type in (mm)	Width in (mm)	Crack Length in (mm)	Specimen Ref
Plate: 3 in (76.1 mm) Thick	K,9	F-L	70(294)	122(841)	101(111)	1.717(43.5)	Bend	3.0 (76.1)	6.0(152.2)	3.0 (76.1)
	K,10	I-L	70(294)	113(779)	100(110)	1.958(49.7)	Bend	3.0 (76.1)	6.0(152.2)	3.0 (76.1)

(a) Specimen in accordance with ASTM Recommendations
 (b) Test orientation is not specified but loading and crack propagation directions are in a plane where maximum grain flow, approximately radially symmetric.

COMPOSITION

Al	V	Fe	C	Si	O	N	H
A	6.2	4.2	0.15	0.020	-	-	-
B	6.3	4.3	0.15	0.026	-	-	-
C	5.83	3.78	0.16	-	-	0.022	0.006
D	6.1	4.12	0.13	0.024	-	0.16	0.013
E	6.4	3.9	0.17	0.03	-	0.15	0.008
F	6.3	4.1	0.09	0.025	-	0.18	0.003
G	6.3	4.1	0.13	0.023	-	-	-
H	6.18	3.91	0.07	-	0.17	-	0.004
I	6.54	4.24	0.7	-	-	-	0.001
J	6.13	4.0	0.38	0.11	0.16	-	0.007
K	6.0	4.1	0.5	0.023	-	-	0.002
L	6.3	4.2	0.20	0.02	-	0.07	-
					0.13	0.008	-
					0.009	0.004	

HEAT TREATMENT

1. 1700F (1200K) Air Cool; Age 1000F (811K), 4 Hr
2. 1750F (1228K) 1 Hr, Air Cool; Age 1000F (811K), 4 Hr
3. 1850F (1283K) 30 Min, Water Quenched; Aged 1250F (950K) 4 Hr
4. 1725F (1214K) 1 Hr, Water Quenched; Aged 1050F (839K) 4 Hr, Air Cool
5. 1725F (1214K) 1 Hr, Water Quenched; Aged 1000F (811K) 4 Hr, Air Cool
6. Solution Treated and Welded
7. 1741F (1223K) 1 Hr, Air Cool; 1246F (948K), 1 Hr, Air Cool
8. 1291F (973K), Air Cool
9. 1750F (1228K), 3 hr, Water Quench; Age 1100F (867K), 4 Hr, Air Cool
10. 1700F (1200K), 3 hr, Air Cool; 1100F (867K), 4 Hr, Water Quench
11. 1750F (1228K), 3 hr, Water Quench; 1000F (811K), 4 Hr, Air Cool

TITANIUM, α - β Alloy: 6Al-6V-2Sn (Sheet 1 of 2)

Table 40

Form	Composition, Heat Treatment	Test Orientation	σ_{y} (kg/mm^2)	Yield Strength σ_y (kg/mm^2)	KSI (lb/in^2)	$2.5\left(\frac{K_{IC}}{\sigma_y}\right)^2$	Specimen					
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Ref	
Plate: 1.0 in (25.4 mm) Thick	A,1	L-T	75(297)	186(1283)	33(16)	0.079(2.0) SEN	1.0	(25.4)	5.0	(12.7)	1.6 (40.6) 24	
	A,2	L-T	75(297)	167(1151)	60(65)	0.323(8.2) SEN	1.0	(12.7)	5.0	(12.7)	1.6 (40.6)	
Plate: 1.0 in (25.4 mm) Thick ELI Grade	B,3	L-T	75(297)	179(1234)	30(33)	0.070(1.8) Bend	0.250(12.7)	0.500(12.7)	0.200 (5.1)	0.500(12.7)	0.200 (5.1) 25	
	B,4	L-T	75(297)	171(1179)	34(37)	0.099(2.5) Bend	0.250(12.7)	0.500(12.7)	0.200 (5.1)	0.500(12.7)	0.200 (5.1)	
	B,4	L-S	75(297)	---	38(42)	---	Bend	0.250(12.7)	0.500(12.7)	0.200 (5.1)	0.500(12.7)	0.200 (5.1)
	B,4	L-T	-321(77)	258(1779)	23(25)	0.020(0.5) Bend	0.250(12.7)	0.500(12.7)	0.200 (5.1)	0.500(12.7)	0.200 (5.1)	
	B,4	L-S	-321(77)	259(1786)	25(27)	0.023(0.6) Bend	0.250(12.7)	0.500(12.7)	0.200 (5.1)	0.500(12.7)	0.200 (5.1)	
Bar: 4.5 in (114.3 mm) Dia. Commercial Grade	G,5	L-C	75(297)	184(1269)	31(34)	0.070(1.8) Bend	0.250(12.7)	0.500(12.7)	0.200 (5.1)	0.500(12.7)	0.200 (5.1)	
	G,5	L-C	-321(77)	270(1862)	23(25)	0.018(0.5) Bend	0.250(12.7)	0.500(12.7)	0.200 (5.1)	0.500(12.7)	0.200 (5.1)	
Extrusion: 8.75 in (222 mm) OD 3 in. (76.2 mm) Wall, Extruded at 1675°F (1186K)	H,11	C-R	70(294)	143(986)	69(76)	0.582(14.8) CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	0.75 (19.1)	0.75 (19.1) 117	
	J,12	C-R	70(294)	190(1310)	32(35)	0.071(1.8) CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	0.75 (19.1)	0.75 (19.1)	
Forging: 0.625 in (15.8 mm) Thick B Processed 2100F (1422K)	C,3	(a)	75(297)	170(1172)	38(41)	0.125(3.2) Bend	0.500(12.7)	---	---	---	22	
Forging: 4.5 x 4.5 in (114.3 x 114.3 mm) Vacuum Arc Reheat	D,5	L-T	75(297)	149(1027)	60(65)	0.405(10.3) BFC	0.500(12.7)	3.0	(76.2)	1.0 (25.4)	26	
Forging: 4.5 x 4.5 in (114.3 x 114.3 mm) Vacuum Arc Reheat	D,5	L-ST	-110(194)	181(1248)	56(61)	0.239(6.1) SEN	0.250(6.4)	1.0	(25.4)	0.500(12.7)	16	
Plate: 1.5 in (38.1 mm) Thick	D,6	L-S	-110(194)	184(1269)	50(55)	0.180(4.6) SEN	0.250(6.4)	1.0	(25.4)	0.500(12.7)		
		L-T	-110(194)	195(1344)	41(45)	0.110(2.8) SEN	0.250(6.4)	1.0	(25.4)	0.500(12.7)		
		TS-TS	-110(194)	195(1344)	25(27)	0.043(1.1) CT	0.500(12.7)	1.0	(25.4)	0.500(12.7)		
Plate: 0.5 in (12.7 mm) Thick	D,6	L-T	-110(194)	210(1448)	33(36)	0.063(1.6) SEN	0.250(6.4)	1.0	(25.4)	0.500(12.7)		
	I-L	-110(194)	208(1434)	30(33)	0.053(1.3) SEN	0.250(6.4)	1.0	(25.4)	0.500(12.7)			

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TITANIUM, α - β Alloy: 6Al-6V-2Sn (Sheet 2 of 2)

Table 40 (Cont.)

Form	Composition, heat treat- ment	Test Orien- ta- tion	σ_F σ_{UT}	Yield Strength K_{S1} (MN/m^2)	Typical K_{IC}	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ $\text{KSI}\sqrt{\text{in}}$ (MN/m)	Specimen				
							Type	Thickness in (mm)	Width in (mm)		
Handforging: 1.0 in (22 mm) Thick	F,7	L-T	75(297)	180(1241)	29(32)	0.065(1.7)	Berst.	0.55 (14)	1.02 (26)	0.55 (14)	23
		T-L	75(297)	186(1282)	26(28)	0.049(1.2)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
β Forged: 4.92 in (125 mm) Dia	E,8	L-C	70(294)	139(956)	60(65)	0.466(11.8)	(b)	---	---	---	63
	E,9	L-T	70(294)	178(1227)	32(35)	0.08 (2.1)	(a)	---	---	---	
	E,10	L-T	70(294)	194(1338)	27(30)	0.056(1.4)	(a)	---	---	---	
	F,-	T-S	70(294)	163(1124)	47(51)	0.200(5.1)	(end)	0.5 (12.7)	0.5 (12.7)	1.0 (25.4)	60

(a) Test orientation is not specified but the loading and crack propagation directions are in a plane.
 (b) Where maximum grain flow is approximately radially symmetric.

(b) Specimen in accordance with ASTM Recommendations

COMPOSITION

Al	V	Sn	C	Fe	Cu	O	N	S	P	Zn
A	5.5	5.5	2.0	0.024	0.69	0.73	0.08	0.010	0.003	-
B	5.35	5.34	1.96	0.015	0.59	0.65	0.081	0.018	0.006	-
C	5.4	5.3	2.0	0.022	0.63	0.6	-	-	-	-
D	5.5	5.4	1.9	0.025	0.65	0.64	0.12	0.012	0.005	-
E	5.4	5.4	2.0	-	0.53	-	0.015	0.004	0.002	-
F	5.5	5.5	2.0	0.051	0.68	0.68	0.04*	0.016	0.015*	-
G	5.64	5.32	2.26	0.021	0.59	0.56	0.172	0.007	0.016	-
H	5.9	5.5	2.0	0.02	0.84	0.78	0.16	0.015	0.005	-
I	6.0	5.9	2.0	0.12	0.99	0.97	0.07	0.010	0.004	0.02

HEAT TREATMENT

1. 1550F (1117K), 1 Hr, Water Quenched; Aged 900F (726K), 4 Hr, Air Cooled
2. 1625F (1158K), 1 Hr, Water Quenched; Aged 1200F (922K), 2 Hr, Air Cool
3. 1600F (1144K), 1 Hr, Water Quenched; Aged 1050F (839K), 4 Hr, Air Cool
4. 1650I (1172K), 1 Hr, Water Quenched; Aged 1125I (881K), 4 Hr, Air Cool
5. 1650F (1172K), 1 Hr, Water Quenched; Aged 1050F (839K), 1 Hr, Air Cool
6. 1550F (1117K), 1/4 Hr, Water Quenched; Aged 1050F (839K), 4 Hr, Air Cool
7. Solution Annealed and Aged
8. 1400F (1053K), Air Cooled
9. 1561F (1123K), 1 Hr, Water Quench; 967F (793K), 4 Hr, Air Cool
10. 1741F (1223K), 1 Hr, Water Quench; 967F (793K), 4 Hr, Air Cool
11. 1600F (1144K), 3 Hr, Water Quench; 1300F (978K), 6 Hr, Air Cool
12. 1600F (1144K), 3 Hr, Water Quench; 1000F (814K), 1 Hr, Air Cool

TITANIUM, α - β Alloys: 6Al-6V-4Zr-4Mo, 6Al-2Sn-4Zr-6Mo and 6Al-2Sn-2Zr-2Mo-2Cr (Sheet 1 of 2)

Table 41

Form	Composition, Heat Treatment	Test Orientation	σ_{UTS} (psi)	Yield Strength, KSI (MN/m ²)	Typical K_{IC}	$K_{IV} \left(\frac{K_{IC}}{\sqrt{in}} \right)^2$ MN/m	Specimen				Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
6Al-6V-4Zr-4Mo											
Die Forging; 3.5 in (88.9 mm) Thick, 6 Forged 175F (1228K)	A-1	C-R	70(294)	157(1082)	40(44)	0.162(4.1)	Bend	0.5(12.7)	1.5(38.1)	0.35(8.9)	96
α+β Forged 157F (1130K)	C-S	70(294)	156(1075)	46(50)	0.217(5.5)	4 Pt Bend	0.5(12.7)	1.5(38.1)	0.35(8.9)		
Forging: 4.25 x 6 in (108 x 152 mm), α+β Forged 157F (1130K)	A-1	C-R	70(294)	170(1172)	51(57.)	0.225(5.7)	Bend	0.5(12.7)	1.5(38.1)	0.35(8.9)	
Forging: 4 x 6.2 in (102 x 158 mm), α+β Forged 154F (112K)	A-1	L-T	70(294)	168(1158)	62(68)	0.340(8.6)	4 Pt Bend	0.5(12.7)	1.5(38.1)	0.35(8.9)	
Forging: 4 x 6.2 in (102 x 158 mm), α+β Forged 154F (112K)	I-S	70(294)	160(1103)	49(54)	0.234(5.9)	4 Pt Bend	0.5(12.7)	1.5(38.1)	0.35(8.9)		
Forging: 4 x 6.2 in (102 x 158 mm), α+β Forged 154F (112K)	R-2	L-T	70(294)	153(1055)	41(45)	0.180(4.6)	4 Pt Bend	0.5(12.7)	1.5(38.1)	0.35(8.9)	
6Al-2Sn-4Zr-6Mo	C-4	-	70(294)	151(1041)	45(49)	0.222(5.6)	4 Pt Bend	0.5(12.7)	1.5(38.1)	0.35(2.9)	31
Forging: 1.5 in (38.1 mm) Square 6 Forged 1800F (1255K), Water Quench	C-4	-	70(294)	180(1241)	46(50)	---	---	---	---	---	100
Forging: 2 in (50.8 mm) Thick 6 Forged 1800F (1255K), Water Quench	C-4	-	70(294)	168(1158)	60(66)	---	---	---	---	---	
Forging: 3.5 in (88.9 mm) Thick 6 Forged 1800F (1255K), Water Quench	C-2	C-R	70(294)	169(1165)	22(24)	0.042(1.1)	4 Pt Bend	0.5(12.7)	1.5(38.1)	0.35(8.9)	96
Forging: 4.5 x 6 in (108 x 152 mm) C-3	L-T	-	1)	158(1089)	41(45)	0.168(4.3)	4 Pt Bend	0.5(12.7)	1.5(38.1)	0.35(8.9)	31
α+β Forged, 1650F (1172K) Max	C-2	L-T	70(294)	174(1200)	25(27)	0.052(1.3)	4 Pt Bend	0.5(12.7)	1.5(38.1)	0.35(8.9)	
6Al-2Sn-2Zr-2Mo-2Cr Bar: 4 in (101.6 mm) Dia	O-5	L-	70(294)	160(1103)	62(68)	0.376(9.6)	CT	1.0(25.4)	2.0(50.8)	1.0(25.9)	101
Forging: 1 in (25.4 mm) Thick, 6 Forged 157F	R-L	70(294)	16 .. 131)	51(56)	0.242(6.1)	CT	1.0(25.4)	2.0(50.8)	1.0(25.9)		
α+β Forged	O-7	-	70(294)	158(1089)	74(8.)	0.548(13.9)	CT	1.0(25.4)	2.0(50.8)	1.0(25.9)	
Forging: 1 in (25.4 mm) Thick, 6 Forged 157F	R-L	70(294)	160(1103)	60(65)	0.340(8.6)	CT	1.0(25.4)	2.0(50.8)	1.0(25.9)		

*Ultimate Strength Values

TITANIUM, α - β Alloys: 6Al-6V-4Zr-4Mo, 6Al-2Sn-4Cr-6Mo and 6Al-2Sn-2Zr-2Mo-2Cr (Sheet 2 of 2)

Table 41 (Cont.)

Composite	Form	Composition			σ_{UTS} (MPa)	σ_{UTS} (lb/in ²)	Yield Strength KSI (MPa)	Typical K_{IC} KSI $\sqrt{\text{in}}$ (MN/m ²)	$2.5 \left(\frac{K_{IC}}{K_{IS}} \right)^2$ in (mm) MN/m ²	Specimen Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Ref
		Al	V	Zr										
A	6.18	5.74	4.07	4.20	-	-	-	0.07	0.012	0.014	0.12	0.012	-	
B	6.0N	6.0N	4.0N	4.0N	-	-	-	-	-	-	-	-	-	
C	6.0N	-	4.0N	6.0N	2.0N	0.031	0.15N	-	0.15N	0.15N	0.02N	-	-	
D	6.0N	-	2.0N	2.0N	2.0N	-	-	-	-	-	-	-	0.25N	

HCAF TREATMENT

1. 15.25F (1103K), 4 hr, Air Cool; 950F (873K), 8 hr, Air Cool
2. 1600F (1144K), 1 hr, Water Quench; 1100F (867K), 8 hr, Air Cool
3. 1600F (1144K), 1 hr, Air Cool; 1100F (867K), 8 hr, Air Cool
4. 1675F (1186K), 1 hr, Air Cool; 1100F (867K), 8 hr, Air Cool
5. 1745F (1225K), 1 hr, Water quench; 1000F (811K), 4 hr, Air Cool
6. 1745F (1225K), 1 hr, Oil Quench; 1000F (811K), 4 hr, Air Cool
7. 1745F (1225K), 1 hr, Air Cool; 1000F (811K), 4 hr, Air Cool

LITANIUM & ALLOYS: 13V-11Cr-3Al, 84Co-8V-2Fe-3Al, 11.5Mo-6Zr-4.5Sn, 3Al-8V-6Cr-4Zr-4Mo (Sheet 1 of 2) Table 4:

Form	Compo-	Con-	Yield	Typical	Specimen		
					$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$	Width	Crack
	Heat	Test	Strength	Strength	Type	in (mm)	length
	no.	no.	psi	psi	psi/mm ²	in (mm)	in (mm)
Bar: 1 in (25.4 mm) Dia	A,1	I-SI	300(422)	159(1096)	39(43)	0.150(5.8)	NR
	A,1	I-SI	70(294)	181(1448)	32(35)	0.078(2.0)	NR
	I-SI	-45(230)	200(1379)	28(31)	0.049(1.2)	NR	Di=505(12.8) Di=505(12.8) Di=505(12.8) Di=505(12.8) Di=505(9.5)
Forgin: 0.625 in (15.9 mm) Thick +8 Processed: 1675F (1186K)	B,2	(a)	70(294)	178(1227)	43(47)	0.146(5.7)	Bend 0.500(12.7) ----
Forging: 0.625 in (15.9 mm) Thick B Processed: 2109F (1422K)	B,2	(a)	70(294)	176(1213)	41(45)	0.136(5.5)	Bend 0.500(12.7) ----
Forging: 4 in (102 mm) Thick	A,3	I-I	70(294)	166(1145)	24(26)	0.052(1.3)	Bend 0.500(12.7) 1.5 (38.1) 0.35 (8.9)
8Mo-8-2Cr-5Al Plate: 0.5 in (12.7 mm) Thick Forged at 1930F (1339K)	C,4	I-I	70(294)	195(1345)	45(49)	0.153(3.4)	SIN 0.375(9.5) 1.125(28.6) 0.375(9.5)
Plate: 2 in (50.5 mm) Thick Forged at 1550F (1339K)	D,4	I-I	70(294)	200(1379)	49(54)	0.150(5.8)	SIN 0.375(9.5) 1.125(28.6) 0.375(9.5)
Closed Die Forging: 0.5 in (12.7 mm) Thick 2.5 in (63.5 mm) thick	I,5	I-I	70(294)	181(1248)	38(41)	0.120(2.8)	Bend 0.500(12.7) 1.5 (38.1) 0.300 (7.6)
Forged Bar: 3 in (76.2 mm) Square	I,5	I-I	70(294)	178(1227)	44(45)	0.133(3.4)	Bend 2.5 (63.5) 1.5 (38.1) 0.300(7.6)
Forging: 4 in (102 mm) Thick	I,5	I-I	70(294)	165(1138)	52(57)	0.248(6.5)	Bend (b) ----
Extrusion: Cylinder 8.75 in (222 mm) Ø 3 in (76.2 mm) Wall, Extruded at 1475F (1075K)	G,6	C-R	70(294)	176(1213)	65(69)	0.317(8.1)	Bend 0.5 (12.7) 1.5 (38.1) 0.35 (8.9)
				179(1234)	51(56)	0.203(5.2)	C-F 0.75 (19.1) 1.5 (38.1) 0.75 (19.1) 117
11.5Mo-6Zr-1.5Sn (8M11)	H,7	I-I	70(294)	174(1200)	61(67)	0.305(7.7)	Bend 0.5 (12.7) 1.5 (38.1) ----
Plate: 0.5 in (12.7 mm) Thick	I,8	-	70(294)	166(1145)	51(56)	0.256(5.9)	Bend 0.525(13.3) 1.5 (38.1) ----
Plate: 0.64 in (16.3 mm) Thick	I,9	-	70(294)	150(1034)	65(71)	0.469(11.0)	Bend 0.525(13.3) 1.5 (38.1) ----
62<	I,10	-	70(294)	148(1020)	71(78)	0.573(14.6)	Bend 0.525(13.3) 1.5 (38.1) ----

TITANIUM, B Alloys: TiY-11Cr-3A, 8Mo-8V-2Fe-3Al, 11.5Mo-6Cr-4.5Sn, 3Al-8V-6Cr-4Zr-4Mo (Sheet 2 of 2) Table 42 (Cont.)

Form	Composition, Treatment	Test Orientation	Yield Strength, KSI (lb/in^2)	Typical k_{IC} $\text{KSI}\sqrt{\text{in}}$ ($\text{MN/m}^{3/2}$)	$2.5 \left(\frac{k_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen			Ref	
						Type	Thickness in (mm)	Width in (mm)		
Forging: 4 in (102 mm) Thick	I, J, L	L-T	70(294)	182(1255)	61(67)	Bend	0.5 (12.7)	1.5 (38.1)	0.25 (8.9)	31
Extrusion: 0.97 in (24.6 mm) Dia	K, 12	L-R	70(294)	233(1606)	25(27)	Bend	0.394(1)	0.394(1)	---	113
Extrusion: 0.9 in (22.9 mm) Dia	K, 14	L-R	70(294)	186(1262)	41(45)	Bend	0.394(1)	0.394(1)	---	118
JAl-8V-6Cr-4Zr-4Mo (BC)	K, 15	L-R	70(294)	167(1151)	54(59)	Bend	0.394(1)	0.394(1)	---	
Forging: 4 in (102 mm) Thick	J, 13	L-T	70(294)	158(1089)	53(58)	Bend	0.281(7.1)	1.5 (38.1)	0.35 (8.9)	31
Billet: 6 in (152 mm) Square	J, 13	L-T, ST	70(294)	167(1151)	59(65)	Bend	0.312(7.9)	1.5 (38.1)	0.78 (19.8)	119
COMPOSITION										
V	Cr	Al	Fe	C	Mo	Zr	Sn	N	H	
A	13N	11N	3N	-	0.05N	-	-	-	-	
B	13.5	10.5	3.1	0.16	0.17	-	-	-	-	
C	7.08	-	3.02	2.16	-	8.04	-	-	-	
D	8.09	-	3.02	2.19	-	8.15	-	0.019	0.112	
E	7.81	-	2.95	2.17	-	7.91	-	0.020	0.122	
F	8N	-	3N	2N	0.05N	8N	-	0.305	0.098	
G	8.0	-	2.3	1.8	0.022	8.2	-	0.08N	0.14N	
H	-	-	-	0.03	-	10.71	4.12	0.018	0.031	
I	-	-	-	-	-	11.5	6	0.16	0.097	
J	8N	6N	3N	-	-	4N	4N	-	-	
K	-	-	0.11	244ppm	1C.95	5.86	4.48	20ppm	1515ppm	
HEAT TREATMENT										
1.	1425F (4047K), 0.25 hr; 900F (756K), 72 hr									
2.	1350F (1006K), 2 hr, Air Cool; 1450F (1106K), 0.5 hr, Water Quench; 900F (756K), 20 hr, Air Cool									
3.	1335F (997K), 1 hr, Air Cool; 1450F (1061K), 0.5 hr, Air Cool; 900F (756K), 15 hr, Air Cool									
4.	1500F (1089K), 10 min, Air Cool; 200F (756K), 10 hr, Air Cool									
5.	1475F (1075K), 1 hr, Water Quench; 1000F (311K), 8 hr, Air Cool									
6.	1475F (1075K), 1.5 hr, Water Quench; 1000F (311K), 8 hr, Air Cool									
7.	1350F (1006K), 15 min, Delay 15 sec, Water Quench; 950F (783K), 8 hr									
8.	1600F (1144K), 1 hr, Water Quench; 900F (756K), 8 hr									
9.	1500F (1089K), 1 hr, Water Quench; 950F (756K), 100 hr, Air Cool									
10.	1600F (1144K), 1 hr, Water Quench; 900F (756K), 100 hr, Air Cool									
11.	1325F (992K), 1 hr, Water Quench; 950F (783K), 8 hr, Air Cool									
12.	Extruded at 1800F (1255K), Water Quench; Shagged 5% Reduction in Area; 900F (756K), 8 hr									
13.	1500F (1089K), 0.25 hr, Air Cool; 1050F (839K), 12 hr, Air Cool									
14.	Extruded at 1400F (1033K), Water Quench; Aged 900F (756K), 8 hr, Air Cool									
15.	Extruded at 1500F (1255K), Air Cool; 1400F (1033K), 0.5 hr, Water Quench; 900F (756K), 8 hr, Air Cool									

ALUMINUM, Copper Alloys: 2014, DTD 5020, MID 66, BS L77, BS 193, GB-265 (Sheet 1 of 2) Table 43

Temper	Form	Composition, Heat Treat-ment	Test Oriente-ration	Temp °F °K	Yield Strength, ksi (MN/m ²)	Typical K _{IC} MN/m ²	2.5 $\frac{(K_{IC})^2}{(\sigma_y)^3}$	2.5 $\frac{K_{IC}}{\sqrt{in}}$	Specimen			
									Type	Thickness in (mm)	Width in (mm)	
2014	T651 Plate: 1.0 in (25.4 mm) Thick	A, (a)	L-T	70(294)	67(662)	24(26)	0.371(8.2)	(b)	1.0 (25.4)	.5(8)	1.0 (25.4)	
			T-L	70(294)	66(455)	21(23)	0.253(6.4)	(b)	1.0 (25.4)	.5(8)	1.0 (25.4)	
	Plate: 5.0 in (127 mm) Thick	A, (a)	L-T	70(294)	59(407)	21(23)	0.317(8.1)	(b)	1.0 (25.4)	.5(8)	1.0 (25.4)	
			A, (a)	T-L	70(294)	58(409)	21(23)	0.328(8.3)	(b)	1.0 (25.4)	.5(8)	1.0 (25.4)
	Plate: 1.0 in (25.4 mm) Thick	A, (a)	S-L	77(294)	-	19(21)	-	-	-	-	-	
			T-L	-320(78)	-	26(28)	-	(b)	1.02 (25.9)	2.0 (50.8)	1.01(25.6)	
	Plate: 2.5 in (63.5 mm) Thick	A,4	T-S	70(294)	63(355)	24(26)	0.11(9.2)	(b)	-	-	-	
				70(294)	64(411)	30(33)	0.549(13.9)	SE	0.594(15.1)	3.0 (38.1)	-	
	T6510 Extrusion: 0.625 in (15.9 mm) Thick	A, (a)	L-T	70(294)	-	-	-	-	-	-	-	
			A, (a)	T-L	70(294)	62(427)	25(27)	0.406 (10.3)	SEN	0.312(7.9)	1.940(25.9)	
	Extrusion: 1.755 in (44.6 mm) Thick	B,1	L-T	70(294)	67(662)	25(27)	0.358(8.8)	Bend	0.750(17.1)	1.5 (38.1)	-	
			C,1	T-L	70(294)	65(448)	19(21)	0.214(5.4)	Bend	0.750(19.1)	1.5 (38.1)	
	Forging: 2.0 in x 8.0 in (50.8 x 203.2 mm)	C,1	L-T	70(294)	63(334)	34(37)	0.728(18.5)	Bend	1.50 (38.1)	5.0 (76.2)	-	
			C,1	T-L	70(294)	59(402)	23(25)	0.380(9.7)	Bend	1.50 (38.1)	5.0 (76.2)	-
	C,1	S-L	70(294)	57(393)	19(21)	0.278(7.1)	Bend	1.50 (38.1)	3.0 (76.2)	-	-	

DTD 5020

KP Plate: 3 in (76.2 mm)
1 in (25.4 mm)
Thick

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 0.413 (10.5) (b)
 0.314 (10.5) (b)
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LUMINUM, Copper 11%., 2014, 0111 5020, H110, H111, H115, H117.

Table 45 (Cont.)

Temper	Form	Composition,		Test Orientation	Temp. °F (°K)	Yield Strength KSI (MN/m ²)	K_{IC} $KSI\sqrt{in} \left(MN\ m^{-1/2} \right)$	Properties		Thickness in (mm)	Type	Width in (mm)	Crack Length in (mm)	Specimen Ref.
		Heat Treatment	Treatment					$\frac{K_{IC}}{K_{YS}}$ $2.5 \left(\frac{K_{IC}}{K_{YS}} \right)^2$	in (mm)					
H11D 66														
WP	Plate: 0.5 in (12.7 mm) Thick	D,3	I-S	70(294)	62(425)	23(25)	0.344 (8.7)	(b)	---	---	---	---	---	73
ESL-77														
WP	Forging:	E,S	T-S	70(294)	62(429)	19(21)	0.235 (6.0)	(b)	---	---	---	---	---	---
ESL-95														
WP	Plate: 1.5 in (38.1 mm) Thick	E,2	I-T	70(294)	63(437)	23(25)	0.333 (8.5)	(b)	---	---	---	---	---	65
CB-265														
WP	Plate: 2.5 in (63.5 mm) Thick	F,6	T-L	70(294)	41(283)	19(21)	0.54 (13.6)	DCB	1.5 (38.1)	10	(254)	3.8 (93)	83	

- (a) Fabrication and Heat Treatment in accordance with Applicable Military, Federal, NSIM or Aluminum Association Specifications.
 (b) Specimen in accordance with ASTM specifications.

COMPOSITION

Cu	Mg	Si	Fe	Al	Cr	Ti	Ni	Pb
A 4.5%	0.5%	1.0%	1.0%	0.25%	0.1%	0.15%	-	-
B 4.58	0.6%	0.94	0.22	0.72	0.08	0.04	-	-
C 4.41	0.50	0.97	0.24	0.73	0.14	0.04	-	-
D 4.38	0.62%	0.75%	1.0%	0.8%	0.2%	-	0.2%	-
E 4.15	0.55%	0.7%	0.5%	0.8%	0.2%	-	0.2%	-
F 4.04	0.66	0.8%	0.42	0.74	-	0.04	-	-

HEAT TREATMENT

1. Solution heat treated, cold worked and artificially aged in accordance with MIL Specification MIL-A-6086H and Aluminum Standards and Data.
- 65**
1. Water Quench; Age 319-373°F (433-463K)
 2. Water Quench; Age 310-364°F (423-458K)
 3. Water Quench; Stretch 1.5-3%; Age 340°F (444K), 8-12 hr
 4. Water Quench; Age 319-373°F (433-463K)
 5. Water Quench; Age 319-373°F (433-463K)
 6. Water Quench; Age 319°F (433K), 10 hr

ALUMINUM, Copper Alloy: 2020

Table 44

Temper Form	Composition, Heat-Treat- ment	Test Oriente- tion	Temp °F °K	Yield Strength KSI (lb/in^2), KSN/ $\sqrt{\text{in}}$	Typical K_{IC} $2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ $\frac{3}{\pi}$ in (mm)	Specimen		
						Type	Thickness in (mm)	Width in (mm)
T6S1	Plate: 1.375 in (34.9 mm) Thick	A, (a)	L-T	70(294)	76(524)	22(2A)	0.209 (5.3)	Bend 1.375(34.9) 3.0 (76.2) ---
			T-L	70(294)	77(531)	18(21)	0.152 (3.9)	Bend 1.375(34.9) 3.0 (76.2) ---

(a) Heat Treatment in Accordance with Applicable Military, ASTM or Aluminum Association Specifications.

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Cl	Li	Tl
A	4.5N	0.03N	0.4M	0.4N	0.5N	0.25N	0.23N	1.3N	0.1M

ALUMINUM, Copper Alloy: 2021 and 2219 (Sheet 1 of 2)

Table 45

Temper	Form	Composition, Heat Treatment	Test Orientation	Temp °F °C	Yield Strength KSI (MPa)	Typical K_{JC} $(MN/m^{3/2})$	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen			Crack Length in (mm)	Ref.
								Type	Thickness in (mm)	Width in (mm)		
2021 T6		A, --	T-S	70(294)	60(414)	23(25)	0.36" (0.3) (b)	---	---	---	---	6.0
2021 T81	Plate: 1.0 in (25.4 mm) thick	C, I	T-L	70(294)	61(421)	23(25)	0.355" (0.0) Bend	1.0 (25.4)	-	-	-	4
			T-L	-100(200)	65(448)	27(27)	0.131(10.9) Bend	1.0 (25.4)	-	-	-	-
			T-L	-321(78)	73(503)	32(35)	0.480(12.2) Bend	1.0 (25.4)	-	-	-	-
		A, (a)	T-L	-123(22)	80(552)	10(44)	0.625(15.9) CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	5.8	
		B, 2	L-T	70(294)	65(448)	27(27)	0.431(10.9) Bend	0.500(12.7)	1.0 (25.4)	0.500(12.7)	4.5	
			T-L	-321(78)	73(503)	32(35)	0.480(12.2) Bend	1.0 (25.4)	-	-	-	-
		A, (a)	L-T	70(294)	66(456)	36(39)	0.745(18.9) (b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	3.7	
			T-L	70(294)	65(448)	24(26)	0.542(8.7) (b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	3.7	
		A, (a)	L-T	70(294)	65(448)	26(28)	0.4 (10.3) (b)	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	3.7	
			T-L	70(294)	61(441)	21(25)	0.269(6.8) (b)	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)		
2219 T87	Plate: 1 in (25.4 mm) Thick	B, (a)	L-T	70(294)	58(409)	33.56)	0.809(20.5) S.I.N	1.0 (25.4)	5.0 (127.0)	1.5 (40.0)	4.0	
		B, (a)	T-L	70(294)	55(379)	30(35)	0.743(18.9) S.I.N	1.0 (25.4)	5.0 (127.0)	1.6 (40.6)		
		B, 3	T-S	72(296)	55(379)	37(40)	1.131(28.7) Bend	1.25 (51.8)	2.5 (63.5)	1.25 (31.8)	3.6	
				-320(73)	67(462)	42(44)	0.982(24.9) Bend	1.25 (51.8)	2.5 (63.5)	1.25 (31.8)		
				-423(21)	73(503)	47(31)	1.036(26.3) Bend	1.25 (31.8)	2.5 (63.5)	1.25 (31.8)		

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WBM-19, Copper Alloy: 2021 and 2219 (Sheet 2 of 2)

Table 45 (Cont.)

Temper	Form	Composition, Heat Treatment	Test Orientation	Temp °K	Yield Strength KSI (MN/m^2)	Typical K_{IC} $\text{KSI}\sqrt{\text{in}}$ (MN m^{-2})	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen				
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Ref.
2219 T851	Plate:	B,-	--	70(294)	51(352)	33(36)	1.047(26.6)	Band	1.40 (35.6)	3.0 (76.2)	1.5 (38.1)	44
	Plate: 1 in (25.4 mm) Thick	B,(a)	L-T	70(294)	59(407)	38(41)	1.037(26.4)	SEN	1.0 (25.4)	5.0 (127.0)	1.6 (40.6)	40
			T-L	70(294)	58(408)	37(40)	1.017(25.8)	SEN	1.0 (25.4)	5.0 (127.0)	1.6 (40.6)	
		B,(2)	L-T	70(294)	51(352)	36(39)	1.246(31.6)	(b)	1.375(34.9)	2.75(70.0)	1.375(34.9)	57
	Plate: 1.375 in (34.9 mm) Thick		T-L	70(294)	57(395)	32(35)	0.788(20.0)	(b)	1.375(34.9)	2.75(70.0)	1.375(34.9)	
		B,(a)	T-L	70(294)	50(345)	29(32)	0.841(21.4)	(b)	1.375(34.9)	3.0 (76.2)	1.55 (39.4)	56

(a) Fabrication and heat treatment in accordance with applicable Military, Federal, or Aluminum Association Specification
 (b) Specimen in accordance with ASTM Recommendations

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Al	V	Cr	Cl	Sn
A	6.3%	0.02%	0.2%	0.5%	0.3%	0.1%	0.06%	0.1%	0.18%	0.15%	0.03%
B	6.3%	0.02%	0.2%	0.3%	0.3%	0.1%	0.06%	0.1%	0.18%	0.15%	0.03%
C	6.0%	0.05%	0.07%	0.11%	0.25%	0.01%	0.05%	0.08%	0.13%	0.11%	0.05%

HARDNESS

1. 985F (805K), 2 hr, oil quenched, preaged 300F (422K), 1 hr; stretch 1.5%, maximum 4%.
2. 990F (806K), water quenched, preaged 300F (422K), 1 hr, stretch 1.0%, maximum, aged 525F (456K), 16 hr.
3. Annealed 1550F (1117K) Argon Atmosphere, 8 hr, furnace cool.

ALUMINUM, Copper Alloy: 2024, 2124, DIP 5090 and A-U4G1 (Sheet 1 of 2)

Table 46

Temper	Form	Composition, Heat- Treatment	Test Orientation or Temp. °F. or °K.	Yield Strength KSI (MN/m ²)	Typical K_{IC} $\text{KSI}\sqrt{\text{in}}$ (MN/m ²)	$2.5 \frac{(K_{IC})^2}{\sigma_{ys}}$ in (mm)	Specimen			
							Type	Thickness in (mm)	Width in (mm)	
2024	T851	Plate: 1.375 in (34.9 mm) Thick	A, (a)	T-L	70(294)	64(441)	20(22)	0.244 (6.2) Bend	1.375(34.9) 3.0 (76.2) 1.51(38.4)	
				T-L	-112(193)	69(476)	22(24)	0.254 (6.5) Bend	1.375(34.9) 3.0 (76.2) 1.51(38.4)	
				F-L	-320 (78)	79(545)	22(24)	0.200 (5.1) Bend	1.375(34.9) 3.0 (76.2) 1.51(38.4)	
				T	70(294)	66(455)	24(26)	0.331 (8.4) Bend	1.375(34.9) 3.0 (76.2) 1.51(38.4)	
				A, (a)	70(294)	66(455)	33(36)	0.625(15.9) (b)	---	
				T-L	70(294)	65(448)	32(35)	0.606(15.4) (b)	---	
				L-T	70(294)	62(427)	32(35)	0.625(15.9) (b)	0 (25.4) 2.0 (50.8) 1.0 (25.4)	
				T-L	70(294)	61(420)	25(27)	0.42 (10.5) (b)	1.0 (25.4) 2.0 (50.8) 1.0 (25.4)	
				L-T	70(294)	56(386)	25(27)	0.498(12.6) Bend	0.55 (14) 1.02 (26) 0.55 (14)	
				T	70(294)	56(386)	22(24)	0.386 (9.8) Bend	1.0 (25.4) 2.0 (50.8) 1.0 (25.4)	
				A, (a)	L-T	300(422)	55(379)	27(29)	0.602(15.3) CT	0.73 (19.0) 1.5 (38.1) 0.75 (19.1)
				T-L	300(422)	54(372)	22(24)	0.415(10.5) CT	0.75 (19.0) 1.5 (38.1) 0.75 (19.1)	
				L-T	70(294)	63(434)	27(29)	0.459(11.7) CT	0.75 (19.0) 1.5 (38.1) 0.75 (19.1)	
				F-L	70(294)	64(441)	22(24)	0.295 (7.5) CT	0.75 (19.0) 1.5 (38.1) 0.75 (19.1)	
				L-S	70(294)	61(421)	31(34)	0.646(16.4) CT	0.75 (19.0) 1.5 (38.1) 0.75 (19.1)	
				L-T	-65(219)	67(462)	26(28)	0.376 (9.6) CT	0.75 (19.0) 1.5 (38.1) 0.75 (19.1)	
				T-L	-65(219)	67(462)	23(25)	0.295 (7.5) CT	0.75 (19.0) 1.5 (38.1) 0.75 (19.1)	
				A, (a)	L-T	70(294)	69(476)	30(33)	0.430(10.2) Bend	1.01 (25.7) 3.0 (76.2) ---
				T-L	70(294)	66(455)	18(20)	0.165 (4.2) Bend	0.375 (9.5) 0.937 (23.8) ---	
				B, 1	70(294)	65(448)	24(26)	0.341 (8.7) Bend	0.750 (19.1) 1.5 (38.1) ---	
				B, 1	70(294)	64(441)	22(24)	0.295 (7.5) Bend	0.750 (19.1) 1.5 (38.1) ---	

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ALUMINUM, Copper Alloy: 2024, 2124, DTD 5090 and A-44C (Sheet 2 of 2)

Table 46 (Cont.)

(a) Fabrication and Heat Treatment in accordance with Specifications.

(BB) Specimen in accordance with ASTM Recommendation.

REVIEW ARTICLE

- 1. Solution Heat Treated, Cold Worked and Artificially Aged in accordance with MIL Specification
MIL-H-60849 or Aluminum Standards and Data, Aluminum Association, April 1968**

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ALUMINUM, Copper Alloy: 2618, RR58, UTD 731, CW 0031/4D, A-U2GV

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ALUMINUM, Zn-Mg Alloy: 7001, 7049 and 7050 (Sheet 1 of 2)

Table 48

Temper	Form	Composition, Heat Treatment	Test Orientation 1 in. or °K	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSIN/mm ² (MN/m ^{-3/2})	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen		
							Type	Thickness in (mm)	Width in (mm)
7001	T75 Plate: 1.375 in (34.9 mm) Thick	A, (a)	L-T	70(294)	71(490)	24(26)	0.286(7.3) Bend	1.37 (34.8) 3.0	(76.2) 1.5 (38.1) 38
			T-L	70(294)	70(483)	22(24)	0.247(6.3) Bend	1.37 (34.8) 3.0	(76.2) 1.5 (38.1)
Extrusion: 0.2 in (5.1 mm)	B,	L-T	70(294)	77(531)	20(22)	0.169(4.3) SEN	0.180(4.6) 2.0	(50.6) 0.67(17)	48
Thick		T-L	70(294)	78(537)	20(22)	0.164(4.2) SEN	0.180(4.6) 2.0	(50.8) 0.67(17)	
Forging: 6.0 in (152.4 mm)	B,-	T-L	70(294)	70(483)	21(23)	0.255(5.7) SEN	0.250(6.3) 2.0	(50.8) ---	49
Thick		T-L	70(294)	71(490)	16(17)	0.126(3.2) CN	0.185(4.7) 3.0	(76.3) ---	
S-T	70(294)	---		16(17)	---	NOL	1.0 (25.4) 0.813(20.6) 0.5 (12.7)		
7049	T75 Forging: 5 in (127 mm) Thick	C, (a)	L-	70(294)	64(441)	32(35)	0.62 (15.8) (b)	---	---
			L-T	75(297)	75(517)	28(31)	0.348(8.9) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4) 97
Extrusion, Integrally Stiffened: 18 x 11 x 3 in (457 x 279 x 76 mm)	D, (a)	T-L	75(297)	75(517)	25(27)	0.218(7.1) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)	
		S-T	75(297)	68(469)	20(22)	0.216(5.5) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)	
L-T	-65(219)	L-T	79(545)	25(27)	+	0.250(6.4) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)	
T-L	-65(219)	T-L	78(538)	23(25)	0.217(5.5) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)		
L-T	-65(219)	L-T	73(503)	33(36)	0.511(13) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)		
T-L	70(294)	T-L	68(469)	22(24)	0.424(10.8) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)		
L-T	-65(219)	L-T	77(531)	31(34)	0.477(12.1) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)		
T-L	-65(219)	T-L	70(483)	20(22)	0.264(5.2) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)		
7049	T75 Extrusion: 20 x 3.3 x 3.5 in (508 x 84 x 89 mm)	B, (a)	L-T	70(294)	76(524)	33(36)	0.471(12) C1	1.0 (25.4) 2.0	(50.8) 1.0 (25.4) 97
		T-L	70(294)	69(476)	20(22)	0.210(5.3) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)	
L-T	-65(219)	L-T	80(552)	30(33)	0.352(8.9) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)		
T-L	-65(219)	T-L	72(496)	72(21)	0.174(4.4) CT	1.0 (25.4) 2.0	(50.8) 1.0 (25.4)		

ALUMINUM, Zn-Mg Alloy. 7001, 7049 and 7050 (Sheet 2 of 2)

Table 48 (Cont.)

Temper	Form	Compo- sition, Test Orien- ta- tion	Test Temp °F °K	Yield Strength KSI (MN/m ²)	Typical K_{IC} $\text{MN/m}^{-\frac{3}{2}}$	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm) $\text{MN/m}^{-\frac{3}{2}}$	Specimen				
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Ref
7050 T73651	Plate: 4 in (102 mm) Thick	E, L-T	70(294)	67(462)	35(38)	0.682(17.3) CT	1.25(31.8)	2.5	(63.5)	1.25(38.1)	116
T7E56	Hand Forging: 5 x 10 in (127 x 254 mm)	F,- T-L	70(294)	64(70)	29(32)	0.513(13.0) Bend	0.75(19.1)	1.5	(38.1)	0.75(19.1)	120

(a) Heat Treatment in Accordance with Applicable "Militar", Federal, ASTM or Aluminum Association Specifications.

(b) Specimen in Accordance with ASTM Recommendations.

COMPOSITION

	Cu	Mg	Fe	Si	Mn	Zn	Cr	Ti	Zr
A	2.1N	3.0N	0.4N	0.35N	0.2N	7.4N	0.28N	0.2N	-
B	2.26	3.03	0.16	0.12	0.04	7.61	0.21	0.02	-
C	1.42	2.45	0.13	0.07	0.01	7.5	0.16	-	-
D	1.5N	2.5N	0.35N	0.25N	0.2N	7.6N	0.15N	0.1N	-
E	2.31	2.44	0.07	0.04	0.00	6.35	0.01	0.03	0.13

ALUMINUM, Zn-Mg Alloy: 7007

Table 49

Temper	Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength, ksi (N/m ²)	Typical K_{IC} kSI $\sqrt{\text{in}}$ (MN m ^{-3/2})	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm), Type	Specimen			Ref.
								Thickness in (mm)	Type	Width in (mm)	
7007 T6	Plate: 1.0 in (25.4 mm) Thick	A, (a)	L-T	70(294)	73(505)	44(48)	0.903(23.1)	(b)	1.0 (25.4)	2.0(50.8) 1.0 (25.4) 37	
			T-L	70(294)	69(476)	37(40)	0.719(18.3)	(b)	1.0 (25.4)	2.0(50.8) 1.0 (25.4)	
			T-I.	70(294)	65(448)	32(35)	0.606 (15.4)	CT	1.0 (25.4)	2.0 (50.8) 1.0 (25.4) 58	
			T-L.	-521(77)	80(552)	23(25)	0.207 (5.2)	CT	1.0 (25.4)	2.0 (50.8) 1.0 (25.4)	
			T-I.	-423(22)	85(586)	28(193)	0.271 (6.9)	CT	1.0 (25.4)	2.0 (50.8) 1.0 (25.4)	
T6I36	Plate: 1.0 in (25.4 mm) Thick	δ, 4	L-T	70(294)	73(503)	46(50)	0.999(25.2)	Bond	1.0 (25.4)	2.0(50.8) 1.0 (25.4) 43	
			T-L	70(294)	69(476)	37(40)	0.685(17.4)	Bend	1.0 (25.4)	2.0(50.8) 1.0 (25.4)	

(a) Fabrication and Heat Treatment in accordance with Aluminum Association Specifications.
 (b) Specimen in accordance with ASTM recommendations.

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Ti	Cr	Al
A	0.25%	1.8%	(0.4% total)	0.4%	6.5%	0.04%	0.12%	0.12%	-
B	0.06	1.7%	0.05	0.11	6.21	0.55	0.03	0.11	0.10

HEAT TREATMENT

1. 860°F (734K), Controlled Moderate Quench; Stretched 1.5 to 3%; aged 275°F (408K), 16 hr

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ALUMINUM, Zn-Ng Alloys: 7075, DTD 5050, DTD 5074, RSI 95, AZ 74, and 7175 (Sheet 1 of 4)

Table 50

Temper	Form	Compo- sition, Heat Treat- ment	Test orienta- tion	Temp. °F (°K)	Yield Strength ksi (N/m ²)	Typical K_{IC} $\text{ ksi} \sqrt{\text{in}} \left(\frac{\text{MN}}{\text{m}^2} \right)^{1/2}$	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^{1/2}$ in (mm)	Specimen			Ref
								Type	Thickness in (mm)	Width in (mm)	
T6	Plate: 3 in (76.2 mm) Thick	A, 1	T-S	70(294)	63(435)	26(28)	0.459(11.7)	(b)	---	---	76
T6S1	Plate: 0.5 in (12.7 mm) Thick	A, (a)	T-I.	70(294)	73(503)	25(27)	0.290(7.4)	(b)	0.5	(12.7) 1.0	(25.4) 0.5 (12.7)
	Plate: 1.375 in (34.9 mm) Thick	A, (a)	T-I.	70(294)	74(510)	19(21)	0.165(4.2)	(b)	1.75	(44.4) 5.0	(76.2) 1.75 (44.4)
	A, (a)	S-L	70(294)	---	---	15(16)	---	(b)	1.75	(44.4) 3.0	(76.2) 1.75 (44.4)
	Plate: 1.375 in (34.9 mm) Thick	A, (a)	I-T	70(294)	75(517)	28(31)	0.350(8.9)	Bend	1.375(34.9)	3.0	(76.2) 1.5 (38.1)
	A, (a)	T-I.	70(294)	78(537)	25(25)	0.218(5.5)	---	---	---	---	38
	Plate: 1.375 in (34.9 mm) Thick	A, (a)	T-I.	70(294)	78(537)	21(23)	0.180(4.6)	Bend	1.390(35.3)	5.0	(76.2) 1.5 (38.1)
	A, (a)	T-I.	-112(193)	83(572)	23(25)	0.193(4.9)	Bend	1.390(35.3)	3.0	(76.2) 1.5 (38.1)	
	A, (a)	T-I.	-320(78)	92(633)	25(27)	0.185(4.7)	Bend	1.390(35.3)	3.0	(76.2) 1.5 (38.1)	
	Plate: 4 in (101.6 mm) Thick	A, 2	T-S	70(294)	67(459)	22(24)	0.270(6.8)	(b)	---	---	76
T6S11	Extrusion: 0.688 in (17.5 mm) Thick	A, (a)	L-I	70(294)	79(544)	26(28)	0.277(7.0)	(b)	0.625(15.9)	1.25 (31.8) 0.625(15.9)	57
	A, (a)	T-I.	70(294)	75(517)	25(27)	0.278(7.1)	(b)	0.625(15.9)	1.25 (31.8) 0.625(15.9)		
	Extrusion: 3.5 in (88.9 mm) Thick	A, (a)	I-T	70(294)	75(517)	31(34)	0.427(10.8)	(b)	1.5	(30.1) 3.0 (76.2) 1.5 (38.1)	
	A, (a)	T-I.	70(294)	67(462)	21(23)	0.246(6.3)	(b)	1.5	(30.1) 3.0 (76.2) 1.5 (38.1)		
	A, (a)	S-L	70(294)	61(421)	19(21)	0.242(6.2)	CT	1.0	(25.4) 2.0 (50.8) 1.0 (25.4)	61	
T7351	Plate: 1.375 in (34.9 mm) Thick	A, (a)	T-I.	70(294)	57(393)	28(31)	0.603(15.3)	Bend	1.375(34.9)	3.0 (76.2) 1.5 (38.1)	39
	A, (a)	T-I.	-112(193)	59(407)	28(31)	0.565(16.6)	---	---	---	---	
	A, (a)	T-I.	-320(78)	66(455)	29(32)	0.483(12.3)	---	---	---	---	
	A, (a)	I-T	70(294)	67(462)	33(36)	0.606(15.4)	SLN	1.0	(25.4) 5.0 (127.0) 1.6 (40.6)	40	
	A, (a)	T-I.	70(294)	65(448)	27(29)	0.431(10.9)	---	---	---	---	

Table 50 (Cont.)

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Temper	Form	Composition, Heat Treatment	Test Orientation	σ_y (MPa)	Yield Strength ksi (MN/m ²)	Typical K_{IC}	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ ksi ^{1.5} (MN/m ^{2.5})	Specimen			
								Type	Thickness, in (mm)	Width, in (mm)	Crack Length, in (mm)
Plate: 1.0 in (25.0 mm) Thick	---	I-I	70(294)	58(400)	34(37)	0.859(21.8)	Bend	0.55 (14)	1.02 (26)	0.55 (14)	27
Plate: 2 in (50.8 mm) Thick	A,3	T-T	70(294)	57(393)	28(31)	0.603(15.3)		1.0 (25.4)	2.0 (50.6)	1.0 (25.4)	
Plate: 4 in (102 mm) Thick	I,(a)	I-T	70(294)	66(452)	27(30)	0.418(10.6)	(b)	---	---	---	76
Forging: 1.1 in (27.9 mm) Thick	---	I-I	70(294)	58(400)	33(36)	0.809(20.5)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
Extrusion: 3.5 in (88.9 mm) Thick	A,(a)	I-I	70(294)	58(400)	22(24)	0.359(9.1)		1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
7075 T73511 Extrusion: 0.688 in (17.5 mm) Thick	A,(a)	I-I	70(294)	64(441)	34(37)	0.706(17.9)	(b)	0.625(15.9)	1.25 (31.8)	0.625(15.9)	37
Extrusion: 3.5 in (88.9 mm) Thick	A,(a)	I-I	70(294)	62(427)	30(33)	0.585(14.9)	(b)	0.625(15.9)	1.25 (31.8)	0.625(15.9)	
A,(a)	S-I	70(294)	64(441)	35(38)	0.748(19.0)	(b)	1.5 (38.1)	3.0 (76.2)	1.5 (38.1)		
A,(a)	S-I	70(294)	58(400)	24(26)	0.428(10.5)	(b)	1.5 (38.1)	3.0 (76.2)	1.5 (38.1)		
A,(a)	S-I	70(294)	54(372)	20(22)	0.343(8.7)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)		
7075 T7352 Forging: 2.0 in (50.8 mm) Thick	B,I	I-I	70(294)	65(448)	31(34)	0.569(14.4)	Bend	0.75 (19.0)	1.5 (38.1)	---	41
Forging: 6.0 in (152.4 mm) Thick	C,I	I-T	70(294)	55(379)	40(44)	1.322(33.6)		2.0 (50.4)	4.0 (101.6)	---	
A,(a)	S-I	T-L	70(294)	50(345)	28(31)	0.781(19.9)		2.0 (50.4)	4.0 (101.6)	---	
A,(a)	S-I	T-L	70(294)	49(358)	26(28)	0.703(17.9)		2.0 (50.4)	4.0 (101.6)	---	
Forging: 6.0 in (152.4 mm) Thick	A,(a)	S-I	70(294)	56(386)	22(24)	0.386(9.8)	Bend	0.7 (17.8)	1.4 (35.6)	0.7 (17.8)	111
A,(a)	S-I	T-L	70(294)	56(386)	20(22)	0.319(8.1)	Bend	0.7 (17.8)	1.4 (35.6)	0.7 (17.8)	
A,(a)	I-S	T-L	70(294)	57(393)	30(33)	0.602(17.6)	Bend	0.5 (12.7)	1.0 (25.4)	---	60
7075 Plate: 2 in (50.8 mm) Thick	A,(a)	I-I	80(299)	65(448)	27(29)	0.431(12)	C1	0.8 (20.5)	2.0 (50.8)	1.0 (25.4)	113

Table 36 (Cont.)
WUJUNXIN, Zhang Alios: 7075, WID 5050, ID 5074, USL 93, fl. #4, 7112 (Sheet 3 of 4)

Temper	Form	Composition, Heat-Treatment		Yield strength of F. (σ_y)	Elongation of F. (%)	K _{IC} PSI (lb/in^2)	Typical K _{IC}	$\pm \frac{(\Delta K_{IC})}{(\sigma_y)}$ $\pm \frac{3}{2}$	KSI ² /in ² (MN/m^2)	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Specimen	Ref
		Condition	Past Orientation											
T70.51	Extrusion: 0.688 in (17.5 mm) Thick	A, (a)	L-T	70(294)	67(462)	33(26)	0.636(15.4) (b)	0.625(17.9)	1.25 (31.8)	0.625 (15.9)	1.25 (31.8)	0.625 (15.9)	0.625 (15.9)	37
T70.51	Plate: 3 in (76.2 mm) Thick	A, (a)	T-L	70(294)	64(441)	30(33)	0.549(15.9) (b)	0.625(15.9)	1.25 (31.8)	0.625 (15.9)	1.25 (31.8)	0.625 (15.9)	0.625 (15.9)	37
T70.51	Extrusion: Plate: 3 in (76.2 mm) Thick	F, -	L-T	70(294)	76(527)	25(27)	0.271(6.9) (b)	---	---	---	---	---	---	---
		F, -	L-S	70(294)	76(522)	20(31)	0.339(8.6) (b)	---	---	---	---	---	---	---
		F, -	T-L	70(194)	70(482)	21(23)	0.225(5.7) (b)	---	---	---	---	---	---	---
		F, -	T-S	70(294)	70(482)	22(24)	0.247(6.3) (b)	---	---	---	---	---	---	---
		F, -	S-L	70(294)	65(445)	20(22)	0.237(6.0) (b)	---	---	---	---	---	---	---
		S-T	T-L	70(294)	65(445)	21(23)	0.361(6.6) (b)	---	---	---	---	---	---	---
		S-T	---	70(294)	70(483)	27(29)	0.372(9.40 Bend)	0.38 (9.7)	0.75 (19.1)	0.34 (8.6)	0.34 (8.6)	0.34 (8.6)	0.34 (8.6)	57
		S-T	L-T	70(294)	87(572)	33(36)	0.395(10.0) Bend	0.32 (8.1)	1.5 (38.1)	0.45 (11.4)	0.45 (11.4)	0.45 (11.4)	0.45 (11.4)	62
		S-T	T-S	70(294)	74(510)	24(26)	0.263(6.7) Bend	0.25 (6.4)	0.75 (19.1)	0.23 (5.8)	0.23 (5.8)	0.23 (5.8)	0.23 (5.8)	58
		E, 2	T-S	70(294)	75(514)	24(36)	0.256(6.5) (b)	---	---	---	---	---	---	76
T70.51	Extrusion: Plate: 3 in (76.2 mm) Thick	G, -	L-T	70(294)	60(411)	25(27.5)	0.431(10.8) (b)	---	---	---	---	---	---	76
		G, -	L-S	70(294)	---	22(24)	---	(b)	---	---	---	---	---	---
		Hand Forging: L-T in (28.4 mm) Thick	L-T	70(294)	71(490)	26(29)	0.335(8.5) (b)	---	---	---	---	---	---	27
			L-S	70(294)	67(462)	25(27)	0.347(8.8) (b)	---	---	---	---	---	---	27
		T-S	T-S	70(294)	69(476)	29(32)	0.442(11.2) Bend	6.5 (12.7)	1.0 (25.4)	---	---	---	---	60
			T-S	70(294)	66(455)	18(20)	0.19 (4.7) Bend	0.5 (12.7)	1.0 (25.4)	---	---	---	---	60
		H, 3	L-A	70(294)	80(552)	34(37)	0.452(11.5) (b)	---	---	---	---	---	---	37
		T-L	T-L	70(294)	70(493)	25(27)	0.319(8.1) (b)	---	---	---	---	---	---	37
		S-T	S-T	70(294)	---	21(23)	---	(b)	---	---	---	---	---	37

Al_{1-x}Ni_x, Zn-Ni Alloys: 7075, 5050, 5074, RSL 95, AZ 74, 7175 (Sheet 4 of 4) Table 50 (Cont.)

Ref.	Specimen	Crack Length in (mm)	Width in (mm)	Thickness in (mm)	Type	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Typical K_{IC} $\left(MN/\sqrt{m} \right)^{-\frac{3}{2}}$	KSVMF in (MN/m)	Yield Strength KSI (lb/in ²)	Tensile Strength KSI (lb/in ²)	Test Orientation °F	Heat Treatment Form
1736	Die Forging: 3 in (76.2 mm) Max. Thickness	H,3	L-T	76(294)	72(496)	35(38)	0.591(15)	(b)	---	---	---	---
			T-L	70(294)	67(462)	26(28)	0.376(9.6)	(b)	---	---	---	---
		S-L	70(294)	---	27(29)	---	(b)	---	---	---	---	---
	Forging: 2.5 in (63.5 mm) Square	H,3	T-L	70(294)	66(455)	23(25)	0.304(7.7)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	99
		S-T	70(294)	65(448)	32(35)	0.606(15.4)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	1.0 (25.4)	
		S-T	0(256)	66(455)	27(29)	0.419(10.6)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	1.0 (25.4)	
		S-T	.65(219)	67(462)	26(28)	0.376(9.6)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	1.0 (25.4)	

(a) F_u - Tension and Heat Treatment in accordance with Aluminum Association Specifications.
 (b) Specified in accordance with ASTM Recommendations.

COMPOSITION	<u>Cu</u>	<u>Mg</u>	<u>Si</u>	<u>Fe</u>	<u>Mn</u>	<u>Zn</u>	<u>Cr</u>	<u>Ti</u>	<u>Ni</u>	<u>Pb</u>	<u>As</u>
A	1.6N	2.5N	0.5N	0.7N	0.3N	5.6N	0.3N	0.2N	-	-	-
B	1.6	2.50	0.10	0.13	0.02	5.65	0.19	0.93	-	-	-
C	1.4	2.60	0.10	0.14	0.02	5.68	0.19	0.03	-	-	-
D	1.4N	2.5N	-	0.15N	5.6N	0.2N	-	-	-	-	-
E	1.6N	2.5N	0.4N	0.5N	0.3N	5.8N	-	-	0.05N	0.15N	-
F	0.9N	2.7N	0.5N	0.5N	0.1N	5.85N	-	0.3N	0.05N	0.17N	-
G	0.92	2.5	0.05	0.15	<0.01	5.85	-	-	-	-	0.35
H	2.5N	0.15N	0.25	0.01N	0.01N	5.6N	0.24N	0.4N	-	-	-
I	1.5N	2.27	<0.2	0.23	0.07	5.7	0.18	<0.2	-	-	-

WIRAT TRADES

1. Stress Relieved and Aged to meet requirements of paragraph 4.10 of Federal Spec QQ-367G, Paragraph 4.6.5.1 MIL Spec MIL-A-22771C.
2. 85SF (733K), Water Quenched, Stretch 1.5-2.5; Aged 275F (406K).
3. Proprietary Heat Treatment.

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ALUMINUM, Zn-Mg Alloys: 7178 and T6D 563 (Sheet 1 of 2)

Temper	Form	Composition, Heat-Treat-ment	Test Orientation	Temp $\circ\text{F}$ (K)	Yield Strength KSI (MN/m^2)	K_{IC}	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$	Specimen			Ref.	
								Thickness in (mm)	Type	Width in (mm)		
7178 T651	Plate: 1.375 in (34.9 mm) Thick	A, (a)	L-T	70(294)	83(572)	23(25)	0.192(4.9)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	37
	Plate: 1.6 in (25.4 mm) Thick	A, (a)	T-L	70(294)	78(538)	20(138)	0.164 (4.2)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	61
T6510	Extrusion: 0.18 to 2.3 in (4.6 to 55.9 mm) Thick	A, (a)	T-L	70(294)	81(558)	26(28)	0.257(6.5)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			T-L	70(294)	81(558)	23(25)	0.202(5.1)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			T-L	70(294)	86(593)	21(23)	0.150(3.8)	SEN	0.18 min (4.6)	0.9 min (22.8)	0.4 min (10.2)	42
T7651	Plate: 1.375 in (34.9 mm) Thick	A, (a)	T-L	70(294)	79(545)	21(23)	0.177(4.5)	SEN	0.18 min (4.6)	0.9 min (22.8)	0.4 min (16.2)	
	Plate: 2 in (50.8 mm)	A, (a)	T-L	70(294)	73(503)	26(28)	0.317(8.1)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	37
	Plate: 1.0 in (25.4 mm) Thick	A, (a)	T-L	70(294)	71(490)	21(23)	0.219(5.6)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
T6511	Extrusion: 3.5 in (88.9 mm) Thick	A, (a)	T-L	70(294)	71(490)	22(24)	0.295(7.5)	(b)	2.0 (50.8)	4.0 (101.6)	2.0 (50.8)	
			T-L	70(294)	71(490)	30(33)	0.447(11.3)	(b)	2.0 (50.8)	4.0 (101.6)	2.0 (50.8)	
			T-L	70(294)	71(490)	28(30)	0.391(9.9)	(b)	2.0 (50.8)	4.0 (101.6)	2.0 (50.8)	
			T-L	70(294)	78(539)	23(25)	0.217(5.5)	(b)	1.5 (36.1)	3.0 (76.2)	1.5 (38.1)	
			T-L	70(294)	69(476)	16(17)	0.134(3.4)	(b)	1.5 (38.1)	3.0 (76.2)	1.5 (38.1)	
			S-T	70(294)	62(427)	14(15)	0.127 (3.2)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	61
	Extrusion: 0.688 in (17.5 mm) Thick	A, (a)	L-T	70(294)	83(572)	22(24)	0.175(4.4)	(b)	0.625(15.9)	1.25(31.8)	0.625(15.4)	
			T-L	70(294)	83(572)	20(22)	0.145(3.7)	(b)	0.625(15.9)	1.25(31.8)	0.625(15.4)	
T76511	Extrusion: 0.688 in (17.5 mm) Thick	A, (a)	L-T	70(294)	69(476)	29(32)	0.442(11.2)	(b)	0.525(15.9)	1.25(32.8)	0.625(15.9)	
T662	Extrusion: 0.4 in (10.2 mm) Thick	A, (a)	L-T	70(294)	68(470)	26(28)	0.365(9.3)	(b)	0.625(15.9)	1.25(31.8)	0.625(15.9)	42
			T-L	70(294)	90(620)	23(25)	0.163(4.1)	(b)	0.404(10.3)	1.5 (38.1)	---	
			T-L	70(294)	83(573)	23(25)	0.192(4.9)	(b)	0.512(7.9)	0.940(23.9)	---	

(a) Composition, Fabrication and Heat Treatment in accordance with Aluminum Association Specifications (b) Specimen in accordance with ASTM Recommendations

ALUMINUM, Zn-Yg Alloys: 7178 and DTD 363 (Sheet 2 of 2)

Table S1 (Cont.)

Temp °Cm	Composition, Heat-Treat- ment	Test Orientation	Temp °F (°K)	Yield Strength Ks ¹ (MN/m ²)	Type K _{IC} KSI $\sqrt{\text{in}}$ (MN m ⁻²)	Type $2.5 \left(\frac{K_{IC}}{\sigma_{ys}}\right)^2$ in (mm)	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Ref.
						Type K _{IC}				
DTD 363	W ²	Extrusion	B ₁ - L-T	70(294)	87(600)	28(31)	0.259 (0.6)	Bend	0.8 (20.3)	2.6 (.66)
										0.75 (19.1) 62

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Tl	Cr
A	2.0N	2.75N	0.5N	0.7N	0.3N	6.8N	0.2N	0.29N
B	2.0N	2.7N	-	-	-	6.8N	-	0.3N

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ALUMINUM, Zn-Mg-Mn Alloy; 7039 and 7005

Table 52

Temper	Form	Composition, Heat Treatment	Test Orientation	σ_y ($\sigma_{0.2}$, $\sigma_{0.1}$)	Yield Strength KSI (MN/m^2)	Typical K_{IC} $\text{ksi}\sqrt{\text{in}}$ ($\text{MN/m}^{3/2}$)	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen		
								Type	Thickness in (mm)	Width in (mm)
7039 T6	Lugging: 4.0 in (101.6 mm) Thick	A, 1	T-L	70(294)	57(393)	19(21)	0.277 (7.0) WOL	4.0 (101.6)	10.2 (259)	4 (101.6)
			T-L	0(256)	59(407)	17(19)	0.208 (5.3) WOL	4.0 (101.6)	10.2 (259)	4 (101.6)
1651	Plate: 2.0 in (50.8 mm) Thick	B, 2	T-L	75(294)	49(338)	29(32)	0.877(22.3) Bend	1.75 (44.5)	3.5 (89)	1.75 (44.5)
			"	-100(200)	53(365)	30(33)	0.804(20.4) Bend	1.75 (44.5)	3.5 (89)	1.75 (44.5)
7005	Plate: 5 in (76.2 mm) Thick	C, (a)	I-T	70(294)	53(365)	47(51)	1.966(49.9) Bend	3.0 (76.2)	6.0 (152)	3.0 (76.2)
			T-L	70(294)	52(359)	40(44)	1.479(37.8) Bend	3.0 (76.2)	6.0 (152)	3.0 (76.2)
			S-L	70(294)	48(331)	7.8(31)	0.851(21.6) CT	1.25(31.8)	2.5 (635)	1.25 (31.8)

(a) Fabrication, and Heat Treatment in accordance with Aluminum Association Specification
(b) Specimen in Accordance with ASTM Recommendations

COMPOSITIONS

Cu	Fe	Si	Fe	Mn	Sn	Cr	Ti	Zr
0.1%	2.8%	0.3%	0.3%	0.25%	4.0%	0.2%	0.1%	-
0.01	2.5	0.3%	0.3%	0.25%	3.75	0.2%	0.1%	-
0.1%	1.4%	0.35%	0.35%	0.45%	4.6%	0.13%	0.03%	0.13%

HARD ALUMINUM

1. 8509 (728), 4 hr, Aged 320° (433K), 18 hr
2. 8509 (728), 2.5 hr, Water Quench, Age Room Temperature, 8 hr, Age 320° (433K), 18 hr

ALUMINUM, Zn-Ng-Mn Alloy: 7079

Table 53

Temper	Form	Composition, Heat Treatment	Test Orientation	Temp. of σ_y	Yield Strength, KSI (kg/mm^2)	K_{IC} , ksi/in ($\text{kg}/\text{mm}^{3/2}$)	Typical K_{IC} ²		Specimen		
							Type in (mm)	Thickness in (mm)	Type	Width in (mm)	Crack Length in (mm)
T6	Plate, 1.0 in (25.4 mm) Thick	A, (a)	T-t.	70(294)	75(517)	2.2(24)	0.215(5.5)	SEN	1.0 (25.4)	5.0 (127.0)	1.6 (40.6)
	Forging: 3.0 in (76.1 mm) Thick	A, 1	L-T	75(297)	51(141)	3.2(35)	0.625(15.9)	WOL	2.0 (50.8)	2.25(57.3)	1.0 (25.4)
			T-L	75(297)	64(141)	28(31)	0.503(12.7)	WOL	2.0 (50.8)	2.25(57.3)	1.0 (25.4)
			L-T	~75(214)	69(176)	33(36)	0.570(14.5)	WOL	2.0 (50.8)	2.25(57.3)	1.0 (25.4)
T51	Plate: 1.375 in (34.9 mm) Thick	A, (a)	L-I	70(294)	78(533)	21(34)	0.395(10.0)	Bend	1.375(34.9)	3.0 (~6.2)	1.5 (38.1)
			T-I	70(294)	75(517)	25(27)	0.277(7.0)	Bend	1.375(34.9)	3.0 (~6.2)	1.5 (38.1)
			T-L	~112(193)	61(558)	26(28)	0.258(6.6)	Bend	1.380(35.1)	3.0 (76.2)	1.65(41.9)
			T-L	~320(78)	91(627)	27(29)	0.220(5.6)	Bend	1.380(35.1)	3.0 (76.2)	1.45(36.8)
T6510	Extrusion: 0.5 in (12.7 mm) thick	A, (a)	L-T	70(294)	74(510)	31(34)	0.439(11.1)	SLN	0.5 (12.7)	1.5 (38.1)	0.5 (12.7)
			T-L	70(294)	71(490)	29(32)	0.417(10.6)	SLN	0.5 (12.7)	1.5 (38.1)	0.5 (12.7)
T652	Forging: 2.0 in (50.8 mm) Thick	B, (b)	L-T	70(294)	71(490)	28(31)	0.389(9.9)	Bend	0.75 (19.1)	1.5 (38.1)	---
			B, (b)	70(294)	65(448)	25(27)	0.370(9.1)	Bend	0.75 (19.1)	1.5 (38.1)	---
			C, (b)	70(294)	64(441)	30(33)	0.549(15.9)	Bend	2.0 (50.8)	4.0 (101.6)	---
	Forging: 6.0 in (101.6 mm) Thick		T-L	70(294)	58(400)	24(26)	0.428(10.9)	Bend	2.0 (50.8)	4.0 (101.6)	---
			S-I	70(294)	58(400)	16(20)	0.241(6.1)	Bend	0.5 (12.7)	1.0 (25.4)	---

(a) Fabrication, and heat treat it in accordance with Military, Federal, ASTM or Aluminum Assoc. Specifications
 (b) Fabrication and heat treatment in accordance with Military, Federal, ASTM or Aluminum Assoc. Specifications

COMPOSITION

HEAT TREATMENT

1. Solution treated 830F (717K); aged 5 days at Room Temp.; 240F (389K), 48 hr

	Cu	Zn	Si	Fe	Mn	Cr	Ti
A	0.6%	4.3%	3.3%	0.3%	0.4%	0.2%	0.18%
B	0.76	4.57	3.48	0.11	0.18	0.14	0.03
C	0.72	4.60	3.55	0.10	0.16	0.17	0.15

833<

ALUMINUM, Zn-Ng-Mn Alloys: DTD 5024 and DTD 5094

Temper	Form	Composition, Heat-Treat-Treatment		Test Orientation	Temp. °F (°C)	Yield Strength, ksi (kN/m²)	Typical K_{IC} , MN/m ^{3/2}	2.5 $(\frac{K_{IC}}{\sigma_y})^2$, MN/m ³	Specimen		
		Composition	Heat-Treat-Treatment						Type	Thickness in (mm)	Width in (mm)
DTD 5024											
MP	Forging: 6 x 6 x 11 in (152 x 152 x 279 mm)	A,1	T-S	70(294)	68(471)	19(21)	0.195 (5.0)	(a)	---	---	---
MP	Forging: 6 x 6 x 4 in (152 x 152 x 102 mm)	A,1	S-L	70(294)	70(485)	15(16)	0.115 (2.9)	(a)	---	---	---
DTD 5094											
MP	Forging:	B,-	L-	70(294)	61(421)	24(26)	0.39 (9.9)	Bend 0.32 (8.0)	1.5 (38.1)	0.32 (1.1)	62
			T-	70(294)	60(414)	22(24)	0.33 (8.4)	Bend 0.32 (8.0)	1.5 (38.1)	0.35 (8.9)	
			S-	70(294)	50(400)	14(15)	0.15 (3.8)	Bend 0.32 (8.0)	1.5 (38.1)	0.32 (8.1)	

(a) Specimen in accordance with ASTM Recommendations.

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Cr	Ni	Pb
A	0.5%	2.7%	0.5%	0.5M	0.5N	5.7M	-	-	-
B	0.5%	2.5%	-	-	0.5N	5.5M	0.2M	0.1M	0.05M

HEAT TREATMENT

1. 859F (753K), Water Quenched at 211F (373K); Aged 275F (408K)

ALUMINUM, Zn-Mg-Mn Alloys: 7080 and M-75S

Table 55

Temper	Form	Composition, Heat Treat-ment	Test Orienta-tion	Temp °F °K	Yield Strength KSI (MN/m ²)	Typical K_{IC} $K_{IC} \sqrt{\frac{S}{2}}$	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen		
								Type	Thickness in (mm)	Width in (mm)
7080										
T751	Plate: 1.375 in (34.9 mm) Thick	A, (a)	L-T	70(294)	60(414)	36(40)	0.9 (22.9)	CT	1.0 (25.4)	2.0 (50.8)
T751A	Extrusion: 3.5 in (88.9 mm) T-ck	B, (a)	L-T	70(294)	64(441)	38(42)	0.58 (14.7)	CT	1.0 (25.4)	2.0 (50.8)
T7	Forging: 4 in (102 mm) Thick	— (a)	C-L	70(294)	59(407)	26(29)	0.49 (12.4)	Bend 0.5	1.0 (25.4)	0.5 (12.7)
M-75S	—	C, —	T-I.	70(294)	56(386)	23(25)	0.42 (10.7)	CT	1.0 (25.4)	2.0 (50.8)
M-75S										
COMPOSITION										
		Cu	Mg	Si	Fe	Mn	Zn	Cr	Tl	
A	0.92	2.01	0.014	0.19	0.32	6.25	-	0.03		
B	1.12	2.04	0.04	0.14	0.39	6.08	-	0.03		
C	1.3N	2.5N	-	-	0.25N	6.0N	0.13N	-		

(a) Fabrication and Heat Treatment in accordance with Aluminum Association Specifications.

84<

ALUMINUM: 6061

Table 56

Temper	Form	Composition, Heat-Treatment	Test Orientation σ_f : L-S, T-L	Yield Strength KSI (lb/in^2)	Typical K_{IC} $\text{KSI}\sqrt{in}$	$2.5\left(\frac{K_{IC}}{\sigma_y}\right)^2$ in (mm)	Specimen		
							Type	Thickness in (mm)	Width in (mm)
1651	Plate: 1.5 in (38.1 mm) thick	A, (a)	T-L	70(294)	43(296)	26(28)	Bend	1.5 (38.1)	3.0 (76.2)
			T-L	-112(193)	45(310)	30(33)	Bend	1.5 (38.1)	3.0 (76.2)
1651	Plate: 3 in (76.2 mm) Thick	A, (a)	L-T	70(294)	42(290)	30(33)	Bend	3.0 (76.2)	6.0 (152)
			T-L	70(294)	41(283)	27(30)	Bend	3.0 (76.2)	6.0 (152)
1652	Forging: 9 in (229 mm) Thick	A, (a)	S-L	70(294)	40(276)	21(23)	Bend	3.0 (76.2)	6.0 (152)
			S-T	70(294)	38(262)	23(25)	Bend	1.0 (25.4)	2.0 (50.8)
								1.0 (25.4)	1.0 (25.4)

(a) Fabrication and Heat Treatment in Accordance with Aluminum Association Standards.

COMPOSITION:

	<u>Cu</u>	<u>Mg</u>	<u>Si</u>	<u>Fe</u>	<u>Mn</u>	<u>Zn</u>	<u>Ti</u>	<u>Cr</u>
A	0.28%	1.0%	0.6%	0.7%	0.15%	0.25%	0.15%	0.2%

8.5 <

BERYLLOJIM: S-200

Table 57

Form	Composition, Heat Treat- ment	Test Ori- ent-a- tion	Yield Strength σ_y (N/m^2)	Typical K_{IC} $\text{KSI}\sqrt{\text{in}}$ $\left(\frac{\text{MN/m}}{\text{in}}\right)^{3/2}$	$2 \cdot \sigma_y \left(\frac{K_{IC}}{E_y} \right)^2$		Specimen		
					Type in (mm)	Thickness in (mm)	Width in (mm)	Crack length in (mm)	Ref
Hot pressed: 30 in (762 mm) Dia x 32 in (813 mm) long	A,-	---	70(294)	37(255)	10(11)	0.183(4.6)	Rend	0.5 (12.7)	1.0 (25.4) 0.25 (6.4) 86
Forged: 16 in (406 mm) Dia x 1 in (25.4 mm) Thick	B,-	---	70(294)	61(421)	11(12.1)	0.81 (2.1)	Bend	0.5 (12.7)	1.0 (25.4) 0.25 (6.4)
Hot Pressed: 11 x 12 x 13 in (279 x 305 x 330 mm)	C,-	L-T	-320(-78)	42(289)	7.6(8.3)	0.08 (-2.1)	CT	1.0 (25.4)	2.0 (50.6) 1.0 (25.4) 124
		T-L	-320(-78)	41(283)	8.3(9.1)	0.10 (-2.5)	CT	1.0 (25.4)	2.0 (50.8) 1.0 (25.4)
		L-T	-180(155)	40(276)	8.0(8.7)	0.10 (-2.5)	CT	1.0 (25.4)	2.0 (50.8) 1.0 (25.4)
		L-T	-50(228)	38(262)	3.5(9.3)	0.13 (-3.2)	CT	1.0 (25.4)	2.0 (50.8) 1.0 (25.4)
		L-T	75(297)	36(248)	9.5(10.4)	0.21 (-5.3)	CT	1.0 (25.4)	2.0 (50.8) 1.0 (25.4)
		T-L	75(297)	35(241)	11.2(12.3)	0.31 (-7.8)	CT	1.0 (25.4)	2.0 (50.8) 1.0 (25.4)
		L-T	300(422)	20(138)	9.8(10.7)	0.6 (15.2)	CT	2.0 (50.8)	4.0 (101.6) 2.0 (50.8)
		L-T	500(533)	---	14.6(16.0)	---	CT	2.0 (50.8)	4.0 (101.6) 2.0 (50.8)
COMPOSITION									
	<u>BeC</u>	<u>Fe</u>	<u>C</u>	<u>Al</u>	<u>Mn</u>	<u>Si</u>	<u>Be</u>		
A	16.500	1180	1000	700	40	300	Ba1(ppm)		
B	17.190	1260	1300	400	110	260	Ba1(ppm)		
C	1.1	0.16	0.14	0.07	0.02	0.03	98.5		

86<